PROJECT MANAGEMENT ISSUES ON HAZARDOUS WASTE REMEDIATION SITES

by

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ABSTRACT

The hazardous waste remediation industry has undergone a difficult growing process since its inception in the late-1970's and early 1980's. During this time, the regulatory drivers that forced cleanups of hazardous waste sites created a slow and expensive process. Typically, it took several years at a minimum to move from discovery of contamination to actually cleaning up the site. In addition, remediation projects proved difficult to manage due to the uncertain nature of the contamination and the methods to clean it up.

Now that regulatory agencies, clients, and contractors have over fifteen years of experience in managing projects, methods are emerging that attempt to save time and money in the overall site cleanup. The Environmental Protection Agency (EPA) is becoming more flexible in allowing alternative methods to be used in cleanups, and contractors are becoming more aware of the fundamental differences between hazardous waste projects and the more traditional construction projects.

This thesis first analyzes the problems in the remediation industry in the 1980's. Second, it looks at the project level to determine what aspects of remediation projects present exceptional challenges to the remediation manager, and what the manager can do to mitigate these problems. Third, it looks at a Superfund site in Norwood, Massachusetts where the Army Corps of Engineers is using an innovative contracting method to administer the remdiation. Fourth, the thesis examines a remediation contractor, OHM Remediation Services to see how they have thrived in the industry this decade.

Thesis Supervisor: Charles Helliwell
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ACKNOWLEDGEMENTS

To My wife, Krista,

and my baby girl, Brenna, born June 12, 1995

BIOGRAPHICAL NOTE

The author came to MIT after spending four years as an officer in the United States Army Corps of Engineers. He is a 1990 graduate of the United States Military Academy at West Point wher he majored in civil engineering.

Mr. Diggins was searching for the opportunity to participate in a research group in construction management at MIT, which eventually led to his participation in the Consortium for the Global Environment and the Construction Industry. Participation in this group led to an interest in hazardous waste remediation and how projects have changed over the last fifteen years.

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CHAPTER 1

INTRODUCTION

> *"We've got to change the fundamental ethic of contracting...and break the mold of design and construct. It just doesn't fit. EPA treats a remediation project like designing a dam! It doesn't work. We can conduct a two-month study and know exactly what needs to be done to clean up the site. We've worked on sites with two year designs three to six inches thick and used just six pages of it for cleanup."*[1]

1.0. Overview and Purpose

This quote from the president of a large remediation contractor in the Southwest United States sums up some of the problems that the U.S government has had in trying to cleanup hazardous waste sites. The majority of research projects over the past fifteen years in hazardous waste remediation has focused on developing innovative technologies and developing effective methods to assess a contaminated site. Very little, though, has been written from the contractor's perspective on how to cleanup a site. But in 1995, public and private clients are demanding more cost-effective and timely cleanup results.

In November of 1994, the American public elected a majority of Republicans in the U.S. Congress for the first time in forty years. The Republicans brought with them an agenda that called for significant cuts in government spending. One way they would achieve these cuts was through the use of a cost-benefit approach to spending for programs such as environmental cleanups. No longer, the Republicans claimed, could the government spend billions of dollars analyzing and studying environmental problems unless there was a direct benefit to society through the costs. For example, the government should not spend money to prevent the potential for one person in a million to contract cancer in a lifetime compared to other risks that kill tens of thousands of

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[1]Malot, Jim. Quote from article appearing in the *Environmental Business Journal,* August 1994. Page 5 No author, "Factors for Success Increase in Highly competitive Remediation Market" Volume VII, No. 8.

people each year. In addition, public and private clients have grown weary of spending millions of dollars to identify problems at contaminated sites without actually performing any clean up. These changes in the Congress and clients' frustrations with the slow and expensive remediation process are forcing changes in the way remediation projects are carried out. "We have to do things differently. We have to consider the process and move more quickly from identification of problems to identification of solutions," says Joseph Silvey, the president of Environmental Science and Engineering, Inc., an environmental consulting firm[2].

Throughout the history of the hazardous waste remediation in this country, the emphasis has been on the assessment stage. Now the actual cleanup will become the focus of remediation projects. Evidence of this shift is a recent study by the *Environmental Business Journal* that shows the percentage of dollars to be spent on actual cleanup services is expected to grow to more than 55% of total remediation services in 1998 from 40% in 1989.[3]

As a result of this shift, remediation contractors need to evaluate the services they provide in order to find the best way to provide what the clients want: timely, cost-effective cleanups. The cleanup firms, then, are searching for ways to "stand out in the crowd" and gain a competitive advantage. To do this, many organizations are looking at the overall process for cleaning up a site and searching for "better, faster, cheaper" solutions.

One pattern that is emerging is that the traditional construction method of design-bid-construct is simply not the most efficient way to cleanup a site. Also, many of the traditional construction project management methods are either inadequate or ineffective in remediation projects. Traditionally, government agencies followed the same procurement procedures to managed projects that they had used in construction: hire someone based on qualifications to conduct an assessment, then, given that assessment, hire someone on qualifications to do the design, and finally, hire the low-bid contractor to carry out the design. This traditional method has proven to be ineffective on most cleanup projects.

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[2]Silvey, Joseph. Quote from an article "The New Realism: Juggling Priorities for a Cleaner America." by Jean Parvin. Special Advertising Section in *ENR*, page E3, June 8, 1994.
[3]OHM Annual Report, 1994, p. 8.

Remediation contractors, then, must break from their traditional role of builder and find ways to include themselves earlier in the process. **This is the goal of this research: to analyze a remediation project from the perspective of a contractor and a project manager and determine the best ways to clean up a site.** In order to accomplish this objective, this research has taken the following steps:

Chapter 2 describes the history of the remediation contractor and project management methods used in remediation. When regulations began forcing hazardous waste cleanups in the early 1980's, many contractors struggled to find the right formula to being a successful remdiation contractor. This chapter provides a background of the challenges that the contractor faced that has lead to the current state of the remediation industry. A significant point in this chapter is that contractors have traditionally faced these projects the same way they approached traditional construction projects.

Chapter 3 analyzes the characteristics of hazardous waste remediation projects in order to identify the significant differences between construction and remediation. What challenges does the nature of a hazardous waste site present to a project manager who must control the costs and schedule of a cleanup? These challenges are demonstrated in two cases encountered in the Southwest United States. They are particularly useful because the managers in this region for the Environmental Protection Agency (EPA) compiled the information for these sites from actual cleanups that are typical of most site remediations throughout the United States. There is not a long history of remediation, and so there is not much data on completed cleanups. Therefore, this information is extremely valuable.

Chapter 4 identifies the significant project management issues that a remediation contractor faces and how the issues raised in Chapter 3 affect these methods. This chapter shows how contractors have managed these challenges on actual cleanups in recent years, and it provides insight into what methods are most useful on remediation projects.

Chapter 5 analyzes the U.S. Army Corps of Engineers approach to cleaning up hazardous waste sites. An important development has been the use of the Total Environmental Restoration Contract and the use of partnering on projects. This chapter examines a Superfund site in Norwood, Massachusetts to identify what methods have been effective and ineffective in the cleanup.

Chapter 6 is an analysis of possibly the most successful remediation contractor in the United States: OHM Remediation Services. This chapter shows how an extremely successful contractor has gained a competitive advantage in the market and how it approaches a remediation project. IT demonstrates OHM's capabilities by looking at thei participation in a Total Environmental Restoration Contract in the Tulsa District of the Srmy Corps of Engineers.

Chapter 7 proposes solutions to the issues raised in Chapter 4. This chapter recommends the best methods to cleanup a site and examines the future of remediation to determine the need for future research

CHAPTER 2

BACKGROUND OF THE REMEDIATION INDUSTRY

2.0. Overview

Historically, the cleanup of hazardous waste sites in the United States has been a slow and frustrating process. A review of the history of how the industry evolved is important to understanding the market of today. This history is intended to be from the perspective of the contractor. It is significant to note the important issues that caused the market and the nature of project management at the time the market emerged.

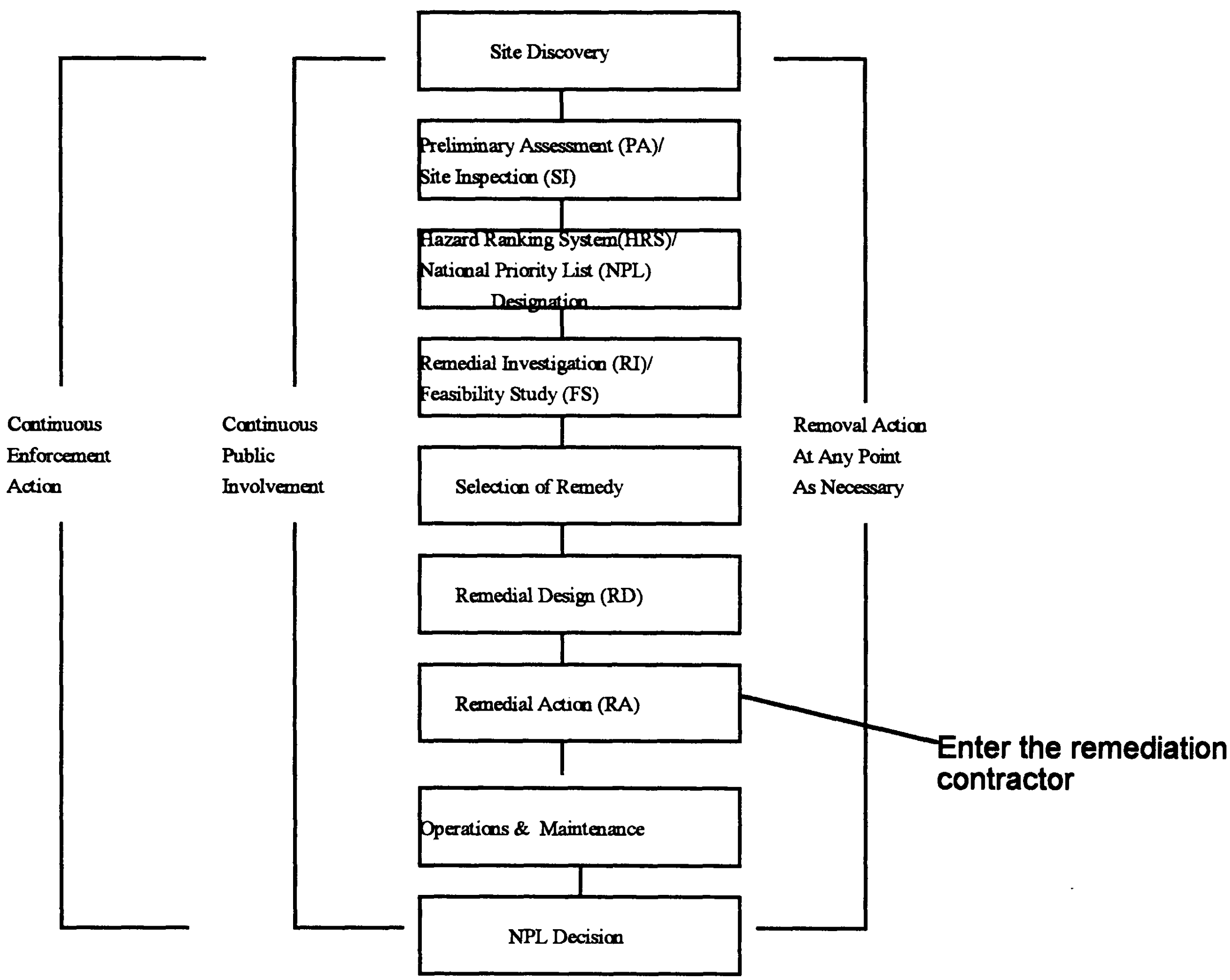
2.1. The Early Years: 1976-1981

The passage of the Resource Conservation and Recovery Act in 1976 marked the beginning of the regulations that brought about cleanup of hazardous waste sites. This act regulated the transport, storage, and disposal of hazardous waste for active industrial facilities. In 1980, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as "Superfund"), which authorized the U.S. Environmental Protection Agency to administer the cleanup of abandoned sites. The initial Superfund authorization was for $1.6 billion and was expected to take four years to complete.

The emphasis of Superfund was first to identify a contaminated site and conduct emergency Removal Action as necessary to eliminate the immediate threat. Then, to ensure that the Superfund money was spent on the most serious problems, and to avoid exhausting the fund on an individual site, Congress required the EPA to rank the site on the National Priority List (NPL) using criteria set forth in a Hazard Ranking System. Once on the NPL, the site would go through a rigorous inspection and evaluation to determine the most appropriate remedy. Also, the EPA would aggressively look for the

Potentially Responsible Parties (PRPs) and attempt to force them to pay for the cleanup. After this lengthy process, the EPA then would start the actual cleanup process. It would procure a design firm according to the guidelines from the Brooks Act, and then it would procure a contractor through the low bid, lump sum method used in all government construction. Figure 2-1 shows the process that the EPA followed to clean up a site.

Figure 2-1. Historic Superfund Process Flowchart
Source: USEPA, Office of Emergency and Remedial Response



At first, this phased process appeared to be a logical methodology to cleaning up a site. Indeed, scientists and engineers were learning about the environmental industry and the nuances of data collection, investigative techniques, and treatment technologies;

therefore, the phased approach was an effective learning tool for them.[4] But to a remedial contractor, there was entirely too much emphasis placed on the first six steps, and not enough on the Remedial Action phase. The emergency Removal Actions would take place early on in a project, but the long-term Remedial Action usually took five to ten years to happen. The biggest reason for these delays was the emphasis on fully-characterizing a site prior to beginning any work. It is understandable that the EPA wanted to fully understand the problem before trying to fix it, but this created years of studies and assessments that often did not help once a contractor started the actual cleanup. Another problem was the bureaucracy that slowed the process from one phase to another. For example, it often took up to two years after the initial investigations for the EPA to decide if the site belonged on the NPL.

Removal and remedial actions were slow to move under RCRA, also. The basic premise of RCRA has been that the owner or operator of the facility is responsible for site cleanups. However, RCRA's liability standard also applies to any party who performs activities at the site, including remedial contractors. This made it extremely risky for a contractor to perform any remedial action under the RCRA laws. Also, the permitting process required in order to perform remedial work was slow and bureaucratic. Private organizations, then, usually fought the regulations instead of paying for a lengthy or expensive cleanup.

Overall, then, the task of cleaning up the nation's hazardous waste sites was seriously underestimated. The following table shows the progress of the 1,236 sites on the National Priorities List as of September 30, 1990, the ten year anniversary of Superfund.

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[4]Spreizer, Gisella M. and Suthan S. Suthersan. "Integrating Remediaiton Approaches: Combining Technology, Risk Assessment, and Environmental Statistics", *National Environmental Journal*. May/June 1993, p. 40.

Table 2-1. Superfund Progress in the First Decade.[5]
Source: ENR, November 26, 1990

Status	# of Sites
RI/FS Begun	1075
Remedy Selected	568
Remedy Design Started	447
Emergency Response Started	421
Remedial Action (Construction) Begun	308
Remedial Action Completed	135
Total Construction Completed	**54**

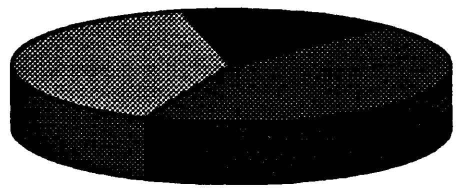
Clearly, this data shows that while many sites have been investigated, only 54 have actually been cleaned to the level that the EPA desires.

2.2. Remediation Contractors: 1980s

By the mid 1980s, the Superfund program was struggling with how to get the cleanups moving. The EPA and the Superfund had become notorious for devoting more funds to litigation among responsible parties and studying sites rather than cleanup.[6] Figure 2-2 shows the results of a study conducted in 1989 by the Office of Technology Assessment (OTA): for every dollar the government spent on Superfund, $0.44 goes to administration, litigation, and related expenses, and $0.16 goes to site studies, leaving only 40 percent of the funds expended for actual cleanup.[7]

[5]Rubin, Debra K. and Steven Setzer. *ENR*, November 26, 1990, p. 41.
[6]"Discernible Shifts in Remediation Market." *Environmental Business Journal*. Vol. 7, No. 8, August 1994, page 3.
[7]Information from article by John B. Miller, "Transaction Costs in Superfund Cleanup as a Function of Joint Liability: Two Proposals for Change." Data obtained from *Coming Clean - Superfund Problems Can Be Solved*, Office of Technology Assessment, OTA-ITE-362 (Washington, D.C.: U.S. Government Printing Office, October 1989).

Figure 2-2. Allocation of Funds by Government on Superfund
Source: Office of Technology and Assessment, 1989



This figure clearly shows that too little money was going toward actual cleanup, and too much toward the bureaucratic process that existed.

In addition to the slow process, the methods used to cleanup these sites at this time were often inadequate. An EPA review of the first three years of Superfund cleanup work showed that 41% of the sites were cleaned by removing soil and transporting it to a landfill. Also, 17% of the sites used the technique of capping, grading, and revegetation.[8] These two methods were popular, but they did not eliminate the problem of the contamination, they simply displaced it.

There were other causes for the slow progress on Superfund projects. From the perspective of project management, the most significant was that many of the contamination problems had never before been experienced. Sites were discovered with complex mixtures of hazardous substances that were reactive and were leaching into nearby surface water or groundwater. As a result of the complexity, conventional and well-tested control technologies often did not exist to address many of the problems found at these sites.[9] Throughout the 1980's many of the projects were long-term and expensive, slowed down by the need to ensure proper characterization of the risks and documentation of the expenditures. Another problem was the nature of cleaning up a

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[8].MIT thesis - Andrew Hoffman, *The Hazardous Waste Remediation Market: Innovative Technology Development and the Growing Involvement of the Construction Industry*, September 1991, page 40.
[9]*EPA Report: Superfund Revitalization: Measures of Success*. January 1994, page 2.

contaminated sites. Few firms had experience with this type of project where the site often looked the same at the end as it did in the beginning. This presents a challenge to a project manager to keep a project progressing without seeing direct results.

Another shortcoming of the Superfund program was in the procurement method to obtain a remediation contractor. In the early 1980's, it nearly always used the fixed price, low bid method of procurement. Due to the uncertainty of many of the projects, this procedure almost always created problems for the contractor. A 1993 study of 34 completed remediation projects in the 80's showed an average of 27% overspending on fixed price contracts.[10]

Congress passed the Superfund Amendments and Reauthorization Act (SARA) in 1986 that increased the size of the Superfund to $8.5 billion. This reauthorization emphasized the importance of developing permanent solutions and highlighted the states' role in making decisions regarding remedial actions. By giving more power to the states to administer projects, the EPA had hoped to speed cleanups. However, initially this only added another layer to the bureaucratic process. Also, by emphasizing generic cleanup standards, SARA had hoped to encourage innovative technologies. This also created problems for the contractor because now it had to completely rethink the methods that it had been working on for so many years. For example, it would no longer be possible to simply transport contaminated material to a landfill, so entirely new techniques would have to be discovered. Generic standards created the problem of often having to clean land to a standard that was nearly impossible or economically unfeasible to obtain. The following example shows the administrative and bureaucratic problems that occurred on a typical Superfund site.

2.2.1. Case Study: The Geneva Industries Superfund Site[11]

The Geneva Industries Superfund Site is a perfect example of how a remediation project progressed throughout the 1980's. The site is an abandoned refinery located in Houston, Texas which manufactured a variety of organic compounds, including

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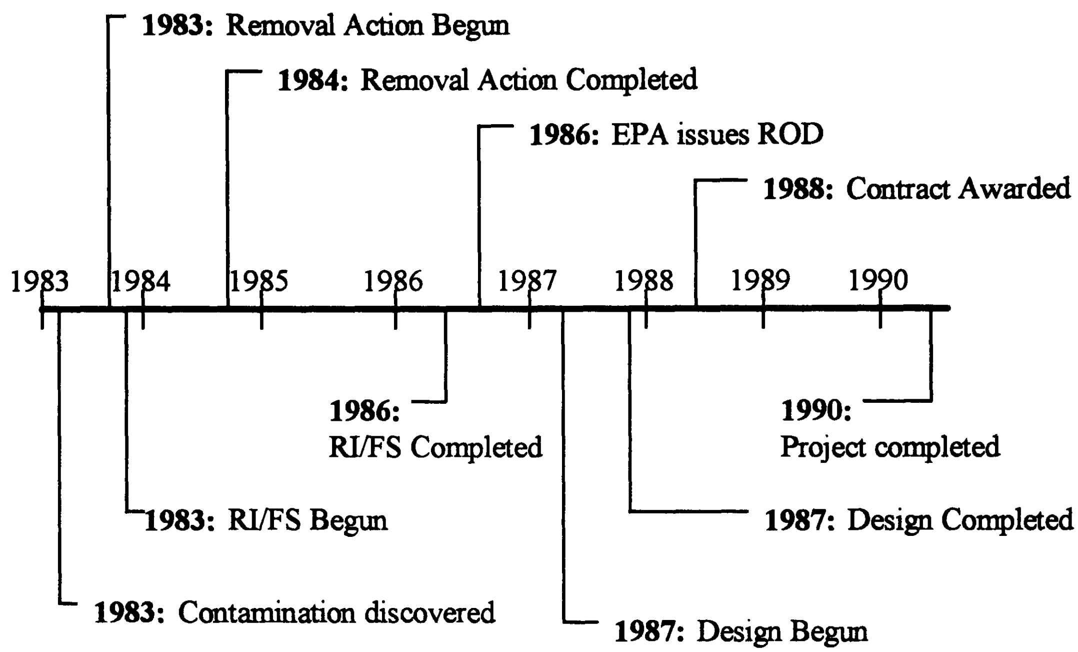
[10]Blanchard, Robert C. and Robert C. Gordon. "Study of Construction Cost Variations at Superfund Sites", presented at the Superfund XIV Conference, November 30, 1993, Washington D.C.
[11]This case study is taken from a case study prepared by Paul B. Cravens of the Texas Water Commission entitled "A Case Study of Change Orders at a Superfund Site: Geneva Industries Superfund Site" for the EPA Hazardous Waste Conference, Dallas, Texas, May 1 and 2, 1991.

polychlorinated biphenyls (PCBs) from 1967 to 1980. There were numerous spills over the history of the plant resulting in several areas of contaminated soil on the ground and in the adjacent drainage ditch.

The EPA discovered the site in 1983 and found numerous spots of soil contaminated with a number of different types of chemicals. A "Planned Removal," or an emergency response was performed from October 1983 to September 1984. This removed the immediate danger to the surrounding area, but it did not address the long-term problems. The site was placed on the National Priority List in September of 1983, making it eligible for funding under the Superfund program.

From December 1983 to May 1986, the Texas Department of Water Resources conducted a remedial investigation, and the EPA issued a Record of Decision (ROD) in September 1986. This ROD called for, in part, the removal and transport of the most contaminated soil to a landfill site in Alabama. The EPA granted funding to the Texas Water Commission to design the remedy set forth in the ROD, and the design was completed in November 1987. The State of Alabama vehemently objected to the transport of material into their state, but the EPA forged ahead with the project anyway. A contract was eventually awarded in December 1987, and work began May 23, 1988 after the EPA issued the Notice to Proceed. On July 22, 1988 the EPA ordered the contractor to delay shipping the soil pending the outcome of the court proceedings, just weeks before it was to begin the shipment. The delay continued until June 7, 1989, when a Federal Judge allowed the transport of the soil. Figure 2-3 shows a timeline of events for this site.

Figure 2-3. Timeline on the Geneva Superfund Site
Source: US EPA Region 6, 1991



The remedial contractor did not get involved in the site until almost six years after the site was discovered and the investigation begun. The Remedial Investigation/Feasibility Study took two and one-half years to complete, and the administrative processes between phases also added time to the lengthy process. The solution of transporting the contaminant over 500 miles was made without the consultation of a remedial contractor, and it eventually met with public opposition causing years of delays. At the end of the project, there were a total of 32 changes during construction, increasing the contract price from $16 million to $20.5 million and delaying the project for over one year. What is striking is that the contamination was not very complex and the remediation itself was a fairly simple project. Many different contractors had the knowledge and the capability to carry out the remediation much sooner, but they were bound to abide by the rules the EPA had established. The process took over seven years to complete a simple remediation. The remedial contractor did not get involved until all of the investigation and design had taken place. The next chapter analyzes the specific reasons for the delays and the overruns.

2.2.2. The Emergence of the Remediation Market

The first firms to capitalize on the $400-$600 million hazardous waste market were solid waste disposal firms since hazardous waste was originally treated in the same fashion as solid waste.[12] Also, there were a number of emergency response firms that performed cleanups of hazardous waste spills and removal actions on Superfund sites.

The next major players to enter into the remediation market were the scientific and engineering firms. These firms dominated the market in the 1980's by performing investigations and studies of contaminated sites. They were particularly successful because the EPA was very concerned about obtaining an accurate assessment and characterization of a site prior to beginning any cleanup. These firms often lacked the project management skills or experience to manage large and complex construction projects.[13] This is where an opportunity developed for traditional construction firms. These firms did have the management skills and the experience to manage a complex project, although they had little experience with hazardous waste remediation.

Throughout the 1980s, then, many contractors struggled to find a niche in the marketplace. Waste managers, emergency response companies, engineering and design companies, and construction firms all had some experience or expertise with one aspect of remediation. Throughout the regulatory changes of the 80's, many sought to stay ahead of the competition by providing as many environmental services as possible. Different types of firms often joined forces in order to broaden their services. Firms such as OHM Remediation Services, decided to grow from emergency response firms or design firms into full-service contractors, providing all types of remediation, assessments, testing, and design.[14] Also, many of the design firms began seeking the management skills necessary to carry out the actual remediation by merging with construction-oriented firms.

Overall, the majority of the work was in assessment and design and not in actual cleanup, so most players in the remediation industry put their effort there. By the end of

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[12]Hoffman, page 22

[13]Ibid.

[14]Rubin, Debra K. "Ohio Cleanup Firm is Heartland's Cash Crop." ENR, July 4, 1994.

the decade, though, it was clear that many of these projects would be moving into remediation, and there were other agencies that would be seeking remediation services. Many firms realized that they would have to give serious consideration to how they were going to manage the projects in the 1990s.

2.3. Remediation Contractors: The 1990s

By 1990, the government and the public had become frustrated with the slow progress of the Superfund program and cleanups administered under RCRA. This has led to three major developments in the remediation industry:

1. The EPA has attempted to change the way it administers projects
2. The passing of the Federal Facilities Act in 1992 has forced the Department of Energy and the Department of Defense to begin cleaning up their facilities
3. Stricter enforcement of RCRA has caused private companies to initiate their own cleanups.

This section will explain each of these developments in more detail. Then, it will show the effects on the players in the remediation industry and the effects on project management.

2.3.1. Changes in the EPA's Approach to Remediation

By 1990, the EPA had begun aggressively searching for quicker and cheaper ways to cleanup a site. Most significantly, the Superfund changed its emphasis of its cleanup program from assessment and litigation to actual cleanup. In order to do this, the EPA has instituted a number of reforms. The first was the introduction of the Superfund Accelerated Cleanup Model (SACM) in 1992. This model combined early actions, such as removing hazardous wastes or contaminated materials, with on-going studies so that immediate public health and environmental threats are eliminated while long-term cleanups are being planned. While the early actions were under way, the EPA would put together a team to determine what additional short-term and/or long-term actions are required.[15] Figure 2-4 is a diagram of the SACM.

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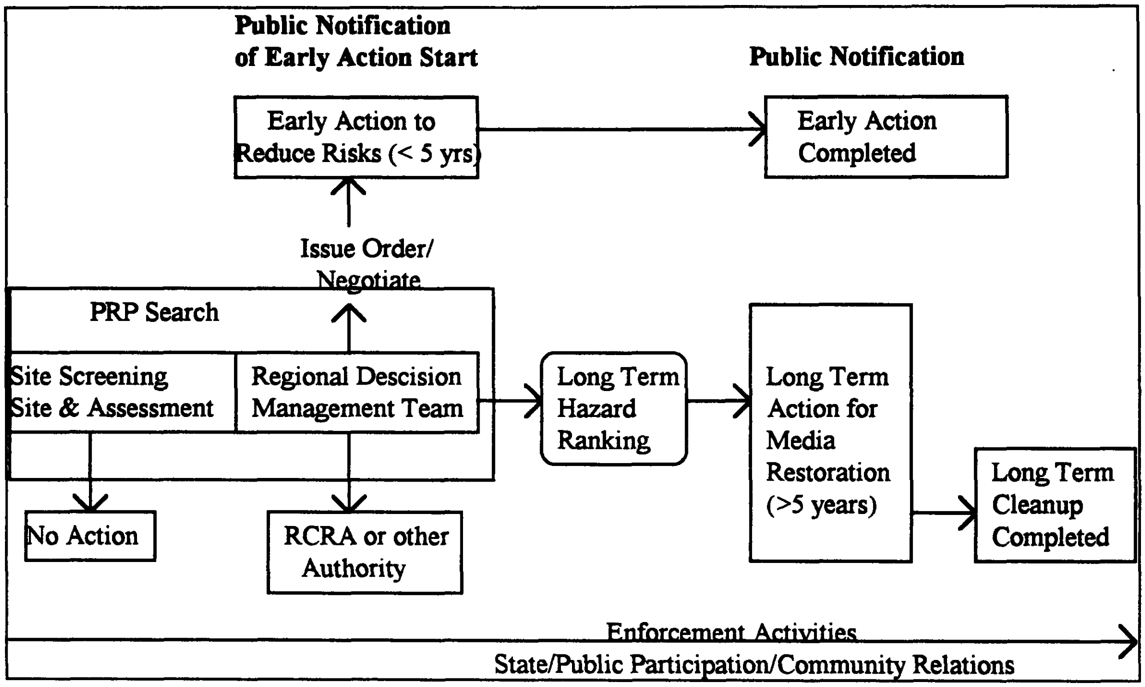
[15] *EPA Report: Superfund Revitalization: Measures of Success*. January, 1994, page ES-v.

Figure 2-4. The Superfund Accelerated Cleanup Model
Source: US EPA Office of Emergency and Remedial Response, 1992



Initially, this model was heralded as a way to get cleanups moving more quickly. Henry L. Longest, the director of the EPA's Office of Emergency and Remedial Response, hailed the SACM as a "revolutionary change that will benefit all major players."[16] He claimed that the SACM will reduce the risks in the Superfund site, dedicate more money to actual cleanup, be cost and time efficient by emphasizing standard remedies and innovative technologies, and will build public confidence.[17] However, the focus of the SACM has been on improving the assessment phase, and little has been done with the SACM to include the contractor any earlier in the process.

Along with the SACM, another important development in the Superfund program has been the use of presumptive remedies. Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on

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[16]Longest, Henry L. "The Superfund Accelerated Cleanup Model: Moving Forward." *Hazardous Materials Control,* Volume 6, No. 2, March/April 1993, page 30.
[17]*Ibid.*

technology implementation.[18] The objective of the presumptive remedies initiative is to use past experiences to streamline site investigations and speed up selection of cleanup actions.[19] This idea also appears to be a step in the right direction. After fifteen years of investigating sites, the EPA should not need excessive time to determine what is the best remedy for each site. This initiative should cause many projects to progress more quickly from discovery to actual cleanup.

The third important recent development in the Superfund program has been the use of "flexible Records of Decision." Traditionally, the Record of Decision (ROD) was the result of years of assessing the site by consulting engineers and the EPA. It would lay out exactly the remedy to be used in the final construction stage. Often, designers and contractors would find the ROD not to be the best solution, but everyone must comply with the directives set forth in the ROD. With a flexible ROD, the EPA has recognized that it sometimes cannot determine the optimum remedy until the contractor actually begins work.

And recently, the EPA made a large step by beginning to use Response Action Contracts (RACs). These contracts allow a firm to manage a project throughout all phases of the process. Most importantly, the contractor is selected by the Brooks Act based on qualifications rather than by submitting the low bid.

2.3.2. Cleaning Up the DOD and the DOE

Defense Secretary Richard Cheney decreed in 1989 that the Department of Defense would be the "federal leader" in the protection of the environment.[20] Shortly thereafter, Thomas E. Baca, deputy assistant defense secretary and the top environmental officer in the DOD, claimed "We've been immensely successful. We've contained our sites, isolated them, and identified them."[21] By 1992, though, these claims appeared to be inaccurate. The closure of military bases in the U.S. identified numerous contaminated sites left behind. Also, the passage of the Federal Facilities Enforcement

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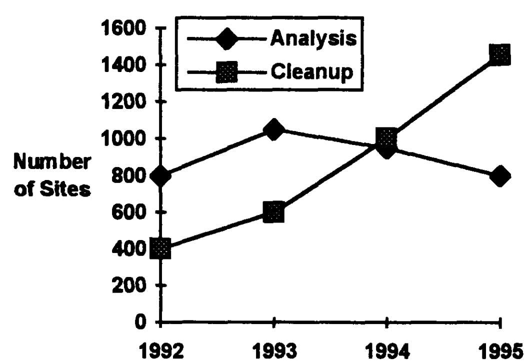
[18]EPA Directive 9355.0-47FS: *Presumptive Remedies: Policy and Procedures*. U.S. EPA Office of Solid Waste and Emergency Response, September 1993.
[19]*Ibid.*
[20]Powers, Mary and Debra Rubin. "The Military's Newest Battlefront," *ENR*. Volume 229, No. 22, November 30, 1992, p. 26.
[21]*Ibid.*

Act in 1992 lifted the protection that federal facilities had from environmental regulations. This exposed the military bases and Department of Energy facilities to the same laws that any other facility must face, and soon the DOE and the DOD were finding enormous environmental neglect on its sites. Since then, DOD has identified more than 17,500 potentially contaminated areas with over 7,000 of these requiring cleanup. Total cleanup costs will be at least $25 billion in 1991 dollars. The DOE has over 4,000 potential areas contaminated with waste, and it plans to spend over $13 billion by the end of the decade on cleaning up its facilities.

Facing the daunting task of cleaning up its bases, the military and the DOE have sought cost-effective and timely results in its cleanups. The military has been particularly aggressive in coming up with cost-effective solutions. It examined the process that the EPA went through in the 1980's and decided that it did not want its projects to become mired in the same bureaucracy that the EPA created. Instead, it wanted to focus on remediation and not on environmental assessments. As a result, the DOD created the Defense Environmental Restoration Program (DERP) to increase DOD's commitment and ability to move sites rapidly from the study phase to actual cleanup. Figure 2-5 illustrates the change in spending in the Department of Defense cleanups.

Figure 2-5. DOD Cleanup Trends
Source: OHM Annual Report, 1994



The DERP and the Base Realignment and Closure (BRAC) program have encouraged remediating sites as quickly as possible while abiding by regulatory criteria.[22] An article in *El Digest*, a publication specializing in market and technology trends in the

[22]"Missouri River Division acquisition Plan for the Total Environmental Restoration Contract", Revision #10, January 25, 1993

environmental business, reports, "While many anticipated that the DOD would eventually shift its cleanup dollars to hard-hat work as the program matured, the pace of actual cleanup work has accelerated as a result of changes to the program aimed at improving progress."[23] This shows that from the beginning of its remediation efforts the DOD has attempted to find methods to cleanup sites quicker and cheaper. The DOE has been slower to move out of the assessment phase of its projects, but it is also looking to avoid the slow process of the Superfund program.

2.3.3. RCRA Enforcement

There are several reasons why more cleanups are occurring in the private sector. First, stricter enforcement by federal, state, and local regulators is forcing companies to respond quickly and establish remediation programs more quickly[24]. For ten years private companies found loopholes in the laws to avoid compliance with them. Now, government agencies have found those loopholes and closed them. Second, companies now see cleaning up the environment as good business that improves their public image. Firms do not want a public relations nightmare that Exxon encountered when it did not respond quickly enough to the Valdez disaster in Alaska. And third, private firms initiating cleanups on their own avoid the more costly government intervention. Firms are finally realizing that they spend more money on legal and administrative costs fighting the government than if they had simply cleaned up their waste on their own.

2.3.4. Effects of Changes on the Industry

The EPA, the Department of Energy, the Department of Defense, and private agencies created a market that is ready to move into actual cleanups and away from assessments. In 1995, it appears that all agencies are poised to execute quicker, cheaper, and faster hazardous waste projects.

Throughout the 1980s, construction accounted for roughly only 40% of the revenues for remediation/construction. This spending is expected to grow to 55% over the next five years. The site remediation market in the United States generated over $7

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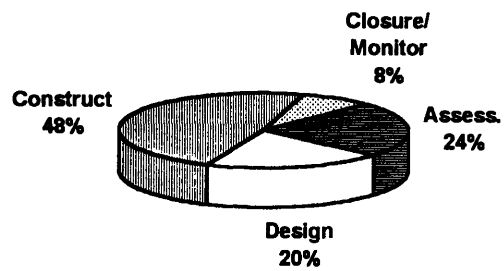
[23]OHM Corporation Annual Report, 1994, p. 7.
[24]Shooter, Douglas and C. Stow Walker. "Remediation Services Market Study," *The National Environmental Journal*, January/February 1993, p. 28.

billion in revenue in 1993, and those figures are expected to continue to rise as the Department of Energy and the Department of Defense begin moving into more remediation. A 1993 study by the *Environmental Business Journal* confirmed the trend of moving toward remediation as consulting firms lost market share to remediation contractors.[25] Figure 2-6 shows the market revenues by service in 1993.

Figure 2-6. Market Revenues by Service, 1993.[26]
Source: Environmental Business Journal, 1994



With clients looking to environmental firms for answers, the industry is now experiencing a consolidation as companies look to provide the services necessary for a cleanup. The current trend is away from hiring companies for isolated services and toward a turnkey remediation contract. Clients are now turning to their contractors not just for answers but for solutions.[27] Certainly, clients will want to focus on the actual cleanup and not want to spend money to determine how dirty the site is.

This will lead to use of full service firms for remediation management. In the 1980s, a full service firm was one that could provide a wide range of environmental services from waste management to asbestos abatement. Now, the term "full service firm" is also used to refer to a company that can execute all stages of a remediation project, from site assessment to closure/monitor.. "If the objective is to shorten the time frame, you want the same team that did the soft engineering to transition that into design

[25]"Discernible Shifts in the Remediation Market." *Environmental Business Journal*, Volume VII, No. 8. August 1994, page 2.
[26]The "Closure/Monitor" portion of this figure refers to long-term monitoring and is not included in the number for construction/remediation.
[27]Contract Flexibility Gives Firms a Competitive Edge". *Environmental Business Journal.* Volume VII, NO. 8, August 1994, page 5.

and construction quickly and efficiently," says Cornelius B. Murphy, president of O'Brien and Gere Consulting Engineers.[28] Given the new focus on the final product, these firms will soon dominate the industry.

The movement toward more cost-effective cleanups will not necessarily lead to more spending on environmental cleanups. What it will mean is that clients want results rather than assessments and designs. Now, environmental firms will have to produce more cleanup results with the same amount of money, which will lead to a more focused effort on the management of these projects. In the past, consulting and engineering firms enjoyed a comfortable profit margin as clients hired them for comprehensive studies. With the shift away from these services, there will be less room for error, a need for top-quality management, and a need to frequently reevaluate company strategies.[29]

2.3.5. Changes in Project Management

The services of the remediation contractor traditionally have been considered to be commodity-based. Clients viewed the consultants and engineers as the professionals who provide the services of assessment and design. With the changes of focus to remediation, this outlook will change. Clients will turn to the contractors as the professionals with the answers, and therefore the contractors need to respond with a professional approach to managing a project. Contractors will have to be capable of assembling a team of experienced professionals who can coordinate a complex project and determine the most appropriate method of remediation

2.4. Summary

When regulatory influence began forcing the cleanup of hazardous waste sites fifteen years ago, few parties in the environmental industry were prepared to manage complexities and challenges of a remediation project. Even the U.S. Government and the U.S. Environmental Protection Agency did not fully understand the task that was before them.

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[28]Parvin, Jean. "New Realities, New Strategies". ENR, Pullout Section on Environmental Engineering, June 6, 1994.
[29]Quote from Parvin, "New Realities, New Strategies."

The regulations have evolved to create a market today that is beginning to give serious consideration to how to effectively manage a remediation site. As we move into the next century, much more emphasis will be placed on the contractor and its ability to efficiently coordinate all phases of a complex remediation. In a panel discussion among ten environmental company executives at MIT in November 1994, nearly all echoed one area that needed to improve for remediation: the need for effective project managers.

The rest of this thesis identifies the most significant areas of remediation that impact on the contractor and the project manager on the site. Then, it analyzes the effects these challenges have on certain aspects of project management. It also examines a Superfund site where remediation is currently in progress using several innovative management techniques. It also looks at one successful company that has adapted to the changes in the market through an aggressive management style. And finally, it makes recommendations for a methodology a remediation contractor can use to become a leader in the industry.

CHAPTER 3

HAZARDOUS WASTE REMEDIATION PROJECTS

3.0. Overview

Hazardous waste remediation projects present unique challenges to a project manager. This chapter first describes remediation projects and their characteristics that present unique challenges to the remediation contractor and the project manager. All of these issues exist in construction, but not to the degree that they do in remediation. The significance of these characteristics on remediation is then demonstrated by analyzing the significant problems encountered on projects conducted in the 1980s in Region 6 of the EPA. Finally, one project from Region 6, the Geneva Superfund Site, is analyzed in more detail to illustrate the impacts that these issues had during the cleanup.

3.1. Remediation Projects

A hazardous waste remediation project involves restoring a certain media of the environment to an acceptable and safe level. Projects vary tremendously in size, type of contaminant, and amount of contamination, but the large projects often have the following characteristics:

- There is a lack of documentation regarding the extent of the cleanup required. Most hazardous waste sites are the victims of years of neglect and illegal dumping of industrial wastes. The parties that caused the contamination did so either knowingly or not, but they most likely did not keep any record of discharges into the environment.
- The contamination is randomly spread throughout a site. Often the contamination did not occur at just one point location, but rather at numerous point sources. Also, once contamination hits the ground or air, it will migrate randomly through the medium.
- There are often several different types of contamination at one installation. An organization that neglected the environment often did so in all of its business

practices. For example, a company could have been dumping its waste from its manufacturing operations into a nearby area, and at the same time its vehicle maintenance facility could have been dumping waste oil into the same or a nearby area.

- There is virtually no economic benefit for a private organization or a public agency in cleaning up the site. Often, the site will appear the same at the end of the cleanup as it did in the beginning.

Once the contamination has been discovered, the EPA or other agency can spend years trying to determine the extent of the problem and a recommended solution. This lengthy and involved assessment process has a significant impact on the final cleanup effort. The assessment process itself does not directly impact the construction or the remediation, but it has enormous effects on the project manager. The remedial project manager must understand the history of the site and the nature of the solution.

The most important factor for the contractor in understanding the assessment process is to determine what areas of risk exist for the project. It is possible that the site has been investigated, assessed, studied, and designed for over ten years prior to the remediation contractor becoming involved in the site. Sometimes as many as ten to fifteen separate investigations were performed for different parties involved in the site, with studies often providing inconclusive results on the extent of the contamination. At the end of an investigation period, a client often will make a determination on how to remediate the site based on the information collected. The age, accuracy, and thoroughness of these studies will then have an enormous impact on the ability of the contractor to carry out a design.

This information is given to an environmental design company which develops a detailed design based on previously collected data.. This design is let out for bids with the low bid contractor winning the job. The contractor must then execute the detailed plan. The client has often considered the actual remediation and execution of the design to be a commodity-based product because all of the difficult work of determining the proper remedy has already been performed.

3.2. Characteristics of Remediation Projects

The process of carrying out a remediation project described above is similar to the traditional construction process used on all government projects and many private jobs. But the significant difference for a remediation contractor is that the remediation is not commodity-based because even after the detailed assessment and design, important uncertainties exist due to the danger and complexity of the hazardous waste. These dangers and complexities lead to the following issues that a contractor must face:

- Unknown Conditions
- Changed Conditions
- Health and Safety Issues
- Public Involvement

The following is a description of each of these issues.

3.2.1. Unknown Conditions

Unknown conditions are conditions completely unanticipated in the plans and specifications, that once discovered, result in additional work or services.[30] The following are examples of unknown conditions that have frequently been found during remediaiton projects:

- contaminants discovered in areas that were believed to be clean
- discovery of buried drums outside the area where the drums were stored
- discovery of contaminants that were not previously discovered on the site
- discovery of unanticipated quantities of contamination

In construction, a project manager can encounter unknown or differing site conditions. Usually, the project manager is handed a detailed set of plans and a design , and his job is to execute that detail. Occasionally, a contractor may perform some work underground where the conditions are not readily apparent before beginning, but normally the engineer's estimate of the conditions is accurate. In typical underground

[30]Cravens, Paul B. "A Case Study of Change Orders at a Superfund Site: Geneva Industries Superfund Site, Houston, Texas." Paper presented at the EPA Hazardous Waste Conference, Dallas, Texas, May 1, 1991.

construction there are usually easily identified areas that can be determined as risky. Also, the entire nature of the project does not hinge on the site conditions as it does in remediation. Instead, they may make the project harder or easier, but they do not change the project altogether.

In remediation, though, unknown conditions occur regularly, particularly since a large amount of the remediaiton is underground. In the early years of remediation, it was common for projects to begin with a design that eventually proved to be completely inaccurate. If the plan was to build a facility to treat a type of contamination and another type was discovered during the excavation, then the entire project will change. An example of this type of problem occurred in Texas at the United Creosoting Superfund Site, where a relatively simple, non-hazardous portion of the cleanup became expensive and drawn out after the contractor discovered asbestos in the buildings after the project had begun.[31]

These unknown conditions lead to scope changes in the project. As the remediation begins, the project manager may be forced to change the scope of the project because of a problem with the original design. Another reason for scope changes is the lack of experience in executing remediation designs. In building construction, there are many different systems that must be carefully integrated in order to construct a building. For example, the workers pouring concrete need to coordinate with electrical or mechanical workers to determine where to leave holes in the concrete for the wiring or the pipes. This coordination happens because the parties involved have experience and they know all of the phases of the project.

In remediation, though, few project managers are experienced enough to know how to make this coordination. An example of this comes from the Geneva Superfund site that is discussed elsewhere in this report. During the design, it was decided to delay the remediation of the ground water until a later date. As a result, some of the activities associated with groundwater remediation were overlooked during the construction design, and the locations for the casings of the pumping wells had to be added after the construction had begun.[32]

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[31].Fite, Mark J. "Change Orders Can Ruin Your Day: An Analysis of Construction in the EPA Region 6 Superfund Program." Case presented to the EPA Hazardous Waste Conference, May 1 and 2, 1991.
[32].*Ibid.*

Another important element of the unknown conditions is the unknown quantity of contamination. This presents one of the most challenging aspects of a remediation project for a contractor. Most remediation projects involve some type of soil and/or water cleanup underground. The simple fact that the contaminant is underground makes it difficult to determine the quantities that need to be cleaned up.

One of the primary goals of the investigation and design phases is to determine the quantities that are contaminated, and then determine the appropriate estimate of the work. Even with a number of new technologies that have improved the ability to characterize a site, determining the quantity has remained perhaps the most difficult task for environmental engineers. Indeed, it is often not until the excavation begins before the true extent of the contamination is known. As a result, the quantities of contamination that were used to base the design on may or may not be valid.

It is also important to note that the unknown quantities could cause the contract price to go up or down. Often the contamination is more severe than originally anticipated, but sometimes the design overestimated the extent of the problem.

3.2.2. Changed Conditions

Changed conditions are conditions that are represented in the plans and specifications, but changed in some manner that result in additional work and services.[33] These can occur when a site has gone through years of investigations and the contamination has changed since the data was taken. A design was developed based on that data, and then the design was given to a contractor. But in the years since the data was collected, the conditions could change in a number of different ways. There could be new contaminants or the existing contaminants could have spread to new areas. Another cause of a changed condition is when the regulations change before the remediation begins. An example of this type of change is in transport of hazardous wastes. States may change a law regarding the legality of transporting certain waste off-site which may cause a plan to change. Changes in regulations or permitting often result in these types of changes.

[33] *Ibid.*

3.2.3. Health and Safety Issues

Hazardous waste projects have risks which are not within normal experiences that are encountered on construction projects. Most construction personnel are not used to the type of work environment that exists on remediation sites. Also, the Occupational Health and Safety Administration (OSHA) estimates that 1.75 million potentially exposed persons work with toxic wastes. Because of the nature of hazardous materials, special and more stringent procedures are followed throughout all operations. This necessitates better education of the crews and more diligent supervision by the foremen and superintendents.[34] Also, when a project is under intense public scrutiny, the management procedures for handling wastes become critical.

The health and safety issues also add a new dimension to the cost of the project. Typically, a remediation site must have a detailed safety plan to protect and decontaminate the employees and the surrounding area. Ensuring that all personnel meet the training requirements to work on the site can be a difficult task for the project manager. A project manager is capable of ensuring his or her own workers are properly certified, but it is more challenging when there are subcontractors on the site with their own employees.

3.2.4. Public Involvement

The public involvement on a hazardous waste remediation project is an extremely complex subject that is usually different for every site. While normally the owner on a project is responsible for handling the public, the public's involvement can also have an effect on the contractor who is attempting to carry out a completed design.

By the time a design is complete and a contract is awarded, the public usually has lost its faith in the remediation players and simply does not trust anyone associated with the site. After finding out that a nearby plant has been contaminating the soil and groundwater for years, the public's frustration mounts while the EPA takes years to determine the appropriate method for cleanup. By the time the remdiation contractor

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[34]Trauner, Theodore J. and J. Scott Lowe. Construction Disputes on Hazardous Waste Projects." Presented to the EPA Superfund Conference, Dallas, Texas, May 1 and 2, 1991.

gets involved in the project, the public most likely has already decided whether or not it will support the remedial action. While most citizens are satisfied that the site is finally beginning the actual cleanup, invariably some citizens and local organizations strongly object to the method of remediation. Add this to the anger and frustration that has been developing over the years and the result is a public that is interested in every movement made on a remediation site.

In the past, remediation contractors have put all of the responsibility for the public on the owner, but recently contractors are finding that they must consider how they are going to manage a site without angering or inciting the public. The project manager, then, must consider the public in nearly every decision made on the site. For example, a truck that leaving the site may have dirt on the tires that falls off the truck and onto the public road. The public will immediately assume that the soil is extremely contaminated, and it will demand a stop to the project.

This section has outlined the most significant aspects of remediation that impact on the manager carrying out the remediation. What is perhaps the most important thing to take from this analysis is that managers and contractors must remain flexible and expect the unexpected on a hazardous waste site. The next section will demonstrate the effects of these aspects by showing the results of a study conducted on a number of Superfund projects located in the Southwest United States.

3.3 Change Orders in the Region 6 Superfund Program[35]

The previous section identified the significant challenges that a project manager faces during remediation. This case study demonstrates the significance of these aspects and show how they can affect the project manager. After ten years of administering hazardous waste remediation projects, some regions of the Environmental Protection Agency sought to capture some of the lessons that it should be learning in order to improve the efficiency of the process. One such effort was conducted by the EPA in Region 6, headquartered in Dallas, Texas. This data is particularly valuable because

[35]The data for this analysis was taken from the case prepared by Mark J. Fite. "Change Orders Can Ruin Your Day: An Analysis of Construction in the EPA Region 6 Superfund Program". The case was presented at the EPA Hazardous Waste Conference, May 1 and 2, 1991.

there is so little information available on complex remediation projects that have been completed.

Nine completed projects and one on-going project which were Federally-funded and conducted by either the state or EPA were analyzed as a basis for the study. The construction activities at these sites were conducted between the years 1987 and 1991, with final construction costs ranging from $133,000 to $20.5 million. The data from this case study produced the following tables:

- The increase in Remedial Action (RA) costs for each of ten projects
- The relationship between remedy type and cost overruns
- The relationship of Remedial Investigation/Feasibility Study (RI/FS) spending to RA cost overruns
- Causes of the Cost Overruns

3.3.1. Increases in Remedial Action Costs

Table 3-1 shows the cost increases on the ten projects. All of these projects were awarded with a lump sum contract. Also, all of the increases or decreases in the contract price were administered through change orders.

Table 3-1. Cost Overruns in EPA Region 6
Source: US EPA Region 6, 1991

Site	Initial Cost ($1,000)	Change Orders ($1,000)	Final RA Cost ($1,000)	Cost Increase (%)
Geneva Industries	16,135	4,386	20,521	**27%**
Old Inger	5,039	2,827	7,866	**56%**
Highlands	4,022	1,397	5,419	**35%**
Bio-Ecology	3,739	1,578	5,317	**41%**
PetroChem	1,690	27	1,717	**2%**
Crystal City	1,092	147	1,239	**13%**
Triangle	507	(27)	480	**-5%**
Odessa 2	389	(45)	344	**-12%**
Odessa 1	170	(11)	159	**-16%**
United Creosoting	96	37	133	**38%**

The column on the right shows significant cost increases on six out of ten projects. The construction method of using a lump sum contract to carry out a project is inadequate when the costs vary so drastically from the original contract amount. These increases can be considered alarming since the sites all had been assessed and characterized for many years.

3.3.2. Relationship Between Remediation Method and Cost Overruns

This study analyzed the effects of different types of remediation method on the management of the project in order to determine if some types of remediation are more prone to poor site characterization and eventually an increase (or decrease) in contract price. The ten Superfund projects involved a number of different types of remedial actions. Table 3-2 shows the relationship between the remedy type and the cost overruns. The italicized sites indicate the sites where the work was considered non-toxic.

Table 3-2. Remedy Type vs. Cost Overruns
Source: US EPA Region 6, 1991

Site	Remedy Type	Cost Increase
Old Inger	Excavate/landfarm	56%
Bio-Ecology	Excavate/Landfill	41%
United Creosote	*Clean/demolition*	*38%*
Highlands	Excavate/off-site	35%
Geneva	Excavate/off-site	27%
Crystal City	Excavate/landfill	13%
PetroChem	*Clean/Road*	*2%*
Triangle	In-situ aeration	-5%
Odessa 2	*Clean/water supply*	*-12%*
Odessa 1	*Clean/water supply*	*-16%*

This table indicates that the projects that were non-toxic construction experienced few changes, while the toxic projects experienced significant changes. There are two exceptions to this trend:

1. The United Creosote site is an exception to this trend because while the demolition/construction on the site was supposed to be non-toxic, a number of the buildings that were to be destroyed were found to have asbestos-backed tiles in the floors. This caused a significant increase in the contract price.
2. The Triangle site actually experienced additional contaminated soil, but the increases were more than offset by the over-estimation of the quantity of trash and debris to be removed.

This data leads to the following three conclusions:

1. Remediation involving toxic work will experience significant changes throughout the project.
2. Remediation involving non-toxic work can be accurately characterized and eventually remediated. A remediation contractor, however, must be prepared for anything, such as finding asbestos on a demolition project.
3. The unique aspects of remediation make it extremely difficult to characterize a site. All of these Superfund sites went through years of investigations, studies, assessments, and designs. In the end, it was the contractor who had to determine the correct quantities and methods to use for the cleanup.

3.3.3. RI/FS Spending vs. RA Cost Overruns

This section shows that an important element in the remediation process is the Remedial Investigation/Feasibility Study phase. This phase is where the site is characterized for the type of contaminant, the extent of the cleanup, and the recommended method of remediaiton. Table 3-3 shows the relationship between the cost of the assessment stage and the cost of the remedial action.

Table 3-3. RI/FS Spending to RA Cost Overruns
Source: US EPA Region 6, 1991

Site	RI/FS Spending (x 1,000)	Ratio of RI/FS to RA Costs	RA Cost Increase
Old Inger	$348	4.4%	**56%**
Bio-Ecology	$357	6.7%	**41%**
United Creosote*	--	--	**38%**
Highlands	$355	6.6%	**35%**
Geneva	$1,065	5.2%	**27%**
Crystal City	$652	53.1%	**13%**
PetroChem	$329	19.2%	**2%**
Triangle	$175	36.5%	**-5%**
Odessa 2	$181	52.6%	**-12%**
Odessa 1	$161	101.0%	**-16%**

* Available RI/FS data covers entire site while RA costs are associated only with interim remedy.
Note: In order to account for the relative size of each project, the ratio of RI/FS spending to total RA costs was compared to the RA cost increase.

If RI/FS spending is taken as a reasonable indicator of the degree and accuracy of characterization of the site, this data confirms that a poorly characterized site will experience significant cost overruns, while sites which are well characterized will experience lower overrun percentages.[36] This shows that while clients now want results instead of assessments, a contractor cannot bypass performing an accurate assessment. He must perform the assessment, but he must do it cheaper and quicker than before.

3.3.4. Causes for the Cost Overruns

The causes of the cost overruns can be placed into one of the following categories:

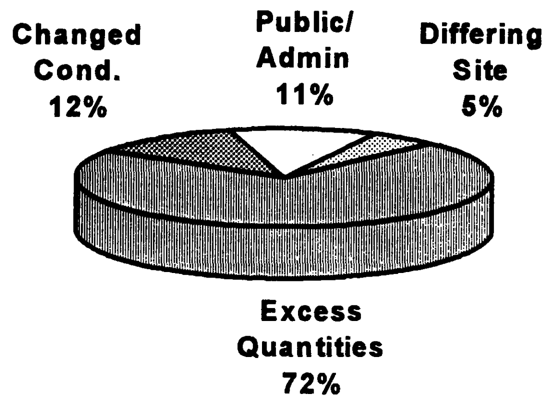
- Excess Quantities
- Changed Conditions (or changes in the scope of the project)
- Differing Site Conditions (Unknown Conditions)

[36]*Ibid.*

- Costs caused by public involvement or administrative requirements that were not identified initially (e.g. necessary permits not received in a timely manner)

Figure 3-1 shows the percentage contribution each category has to the overall cost overruns of the projects in Region 6.

Figure 3-1. Cost Overruns by Category in Region 6
Source: US EPA Region 6, 1991



This chart gives a more detailed picture of what caused the changes in cost on these Superfund projects. If cost is an accurate indication of the ability of a contractor to control a project, then this chart confirms that contractors have had a difficult time trying to manage the aspects of remediation pointed out previously in this chapter. The traditional construction methods, then, need to be adjusted to accommodate the complexities of these projects.

3.4. A More Detailed Look: The Geneva Superfund Site

Chapter 2 introduced the Geneva Superfund Site to show the timeline for how a typical Superfund Site progressed through the 1980's. Here, the Geneva site is used to show what happened to the original contract price and schedule after the remediation contractor was awarded the contract. This site is informative to analyze because it is indicative of most of the remediation projects that took place in the 1980s. It experienced delays and cost increases due to conditions that were not identified during the assessment stage.

3.4.1. Construction History

The Geneva site located in Texas was contaminated by different chemicals in different locations on the property. After a lengthy assessment and design process, a contract for the remediation work was awarded on April 8, 1988 for $16.1 million. The design in part called for the removal and off-site disposal of drums, surface structures, contaminated liquids, and all soils contaminated to a level greater than 50 parts per million (ppm) of PCB's. Also, the contractor was to construct a perimeter slurry trench cut-off wall to contain the soil that was contaminated less 50 ppm. This slurry wall was to tie into the naturally existing clay aquitard, which prevented the downward migration of the contaminants into the water supply.

In order to execute the design, the contractor needed to take the following steps:

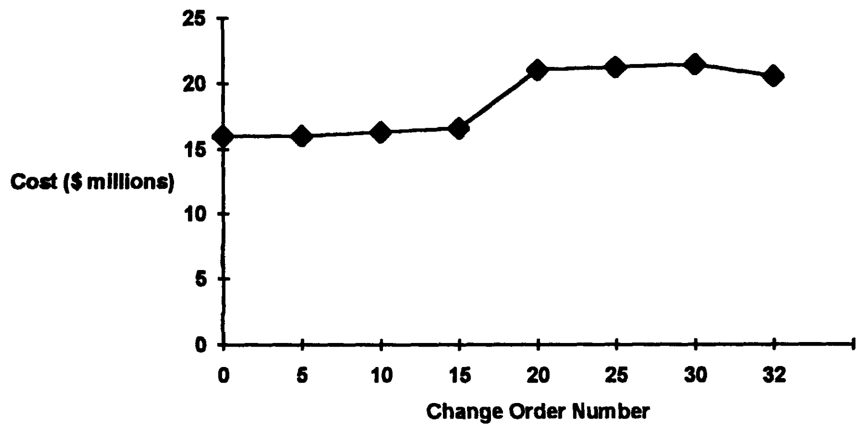
1. Construct a slurry wall while simultaneously excavating and removing soil. The most highly contaminated soil was to be transported to a landfill in Alabama.
2. After completing the excavation, back-fill with imported soil.
3. Upon completion of the backfilling and the construction of the slurry wall, emplace a final protective cap, and erect a security fence around the perimeter of the site.

It is interesting to note that this project is not technically complex. The construction of a slurry wall is something that most construction companies have the capability of performing, and much of the remediation involved excavating the soil and transporting it to an off-site landfill.

3.4.2. Change Order History

There were a total of 32 change orders approved on the project, which raised the contract price from $16.1 million to $20.5 million. There were a total of 25 debit changes worth $5.1 million, and seven credit changes worth over $736,000. Figure 3-2 shows the effects the change orders had on the overall project costs.

Figure 3-2. Cumulative Project Costs
Source: Texas Water Commission, 1991

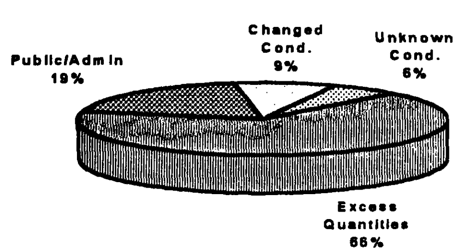


This table indicates that most of the changes had a small impact on the overall cost of the project. Change order number 17 was the most significant because it accounted for the majority of the changes due to the excess quantities that were found. The large number of change orders took the owner's representatives a long time to process, and they created a tense relationship on the site between the contractor and the owner. Now in remediation, clients and owners are searching for a more efficient way to process and manage changes on the site. These methods are discussed in the next chapter.

3.4.3. Comparison of Types of Change Orders

The changes to the cost of the project were placed in the same categories as in the Region 6 case. Figure 3-3 shows a comparison of the types of change orders experienced on the project.

Figure 3-3. Comparison of Types of Change Orders
Source: Texas Water Commission, 1991

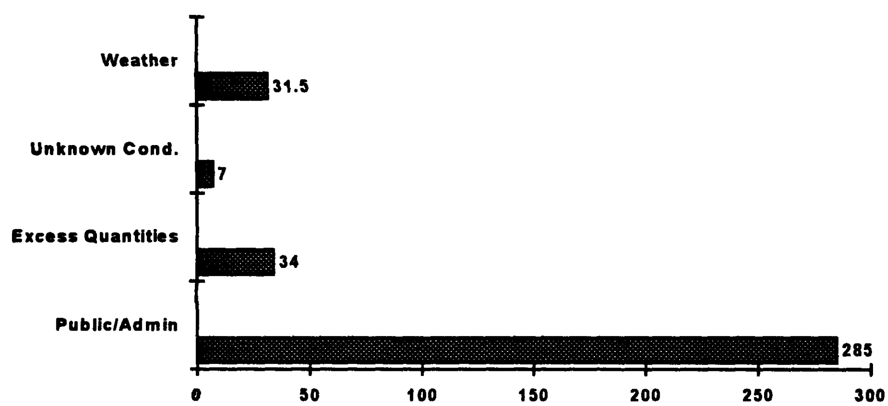


This figure confirms the results of the Region 6 study: the significant cost overruns are the result of the unique characteristics of remediaiton projects. Obviously, the contractor found significantly more contaminated soil than was called for in the design. Another problem on this site was the state of Alabama's attempt to keep the contaminated soil out of its state. Eventually, this effort was stopped by a federal judge, but the issue caused significant cost and time overruns.

3.4.4. Effects of Changes on the Project Schedule

The original schedule for the contractor called for the project to be completed in 331 days. The project ultimately took 761 days. Figure 3-4 shows the causes for these delays.

Figure 3-4. Changes to the Project Schedule
Source: Texas Water Commission, 1991



This figure shows the effect of the categories on the remediation schedule. Obviously, the public's involvement in this project had a significant impact on the schedule. This delay was caused because of the dispute with the state of Alabama This solution met with strong opposition from the public in Alabama, which resulted in a nine month delay while the issue was debated in the courtroom. Interestingly, the issue did not become important until the transport was actually about to take place, instead of occurring during the site assessment or the design process.

3.5. Summary

The purpose of this chapter was to indicate what makes a hazardous waste remediation project so difficult to remediate. It described the following characteristics:

unknown conditions, changed conditions, unknown quantities, health and safety issues, and the public involvement. It then demonstrated these aspects in two cases of Superfund projects conducted in the United States in the 1980s. The next chapter examines how these aspects affect the different functions of the remediation contractor.

CHAPTER 4

REMEDIATION'S IMPACT ON PROJECT MANAGEMENT

4.0. Overview

The last chapter pointed out the most significant aspects of hazardous waste remediation projects that impact a remediation contractor as it attempts to clean up a site. As indicated in Chapter 2, the focus of the remediation market has shifted from assessment and design to actual cleanup. This means that there will be a greater emphasis on the contractor to develop methods to improve the actual remediation process. This chapter will analyze the traditional management roles of the contractor and demonstrate how each is affected by the characteristics of remediation described in the previous chapter. The following aspects of project management are analyzed:

Pre-Construction:
- Contracting
- Estimating
- Scheduling
- Owner/Designer/Contractor Interaction

Construction:
- Cost and Schedule Control
- Change Management
- Quality Control/ Quality Assurance
- Owner/Designer/Contractor Interaction

Post Construction:
- Closure: Documentation and Operations and Maintenance

4.1. Pre-Construction: Contracting

Perhaps the most important aspect that the remediation contractor must understand is the significance of the contracting methods used in remediation. In the early years of remediation, contracts were lump sum, but now there are other methods emerging that have a large effect on the way projects are managed. To be sure, clients in the private sector are demanding flexibility in contracting, and even government agencies are starting to use alternative methods. Most importantly, it is not the *type* of job that creates the potential for profit, it is the *contract mechanism*.[37] This section analyzes each of the following methods in order to show how they affect the contractor's administration of a project: fixed price, reimbursable, indefinite delivery, and client service agreements.

4.1.1. Fixed-Price (Lump Sum)

Most public and private contracts were awarded through a competitively bid lump sum contract when remediation projects moved into the remediation phase in the mid 1980's. The public sector used this method because it treated remediation the same way it did construction, and therefore it was bound by law to bid all projects. In the private sector, fixed-price contracts were used because that was the method that owners and contractors were most familiar with.

Prior to the bid, the nature of the lump sum contract leaves the contractor in a dilemma that is often found in construction. The bid documents contain detailed specifications, but in order to win the contract the contractor must make assumptions that ignore potential problems. An experienced contractor generally knows when a particular project is most likely to encounter problems that are not in the plans, however, he would have to ignore these signs to get the job. Once awarded the contract, the contractor knows that he must submit change orders to cover the increased costs and time necessary to deal with these problems.

A lump sum contract does have a mechanism in which to effectively manage the changes inherent in remediation. The unknown conditions, the possible inaccuracies of the assessment of the site, and the public involvement all can cause the costs on the project to increase dramatically. Contractors must resort to submitting change orders which often take time to process and lead to an acrimonious relationship between the contractor and the owner. The two sides struggle to determine what claims are justified or not.

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[37]"Contract Flexibility Gives Firms a Competitive Edge". Environmental Business Journal. August 1994, p. 5.

Another fundamental problem with the lump sum method is the allocation of risk. By locking in a contractor to a specific price, the owner is attempting to transfer the risk of cost and time overruns to the contractor. The contractor, though, cannot manage those risks because he does not have the ability to control the conditions of the ground. Also, the contractor cannot control an issue such as the public becoming involved to slow down the progress of a site.

The EPA recognized problems with the lump sum method of contracting by the mid-1980's. In June 1986, it recommended establishing a change order contingency of 8-10% for remedial actions. In 1991, it began recommending other methods to use contingency funds. The following table was suggested in the EPA's Region 6.

Table 4-1. Suggested Contingencies[38]
Source: US EPA Region 6, 1991

	Contingency for a Given Level of Uncertainty		
Remedy Type	**Low**	**Medium**	**High**
Non-Hazardous	5%	10%	N/A
Simple Hazardous	15%	20%	30%
Complex Hazardous	25%	35%	45%

Given that government agencies have been bound to use the lump sum method, developing this type of table is a common method to deal with the unknowns of remediation. However, even this approach is somewhat arbitrary and ignores the tremendous uncertainties involved in construction.

Examples of the Low-Bid Approach:

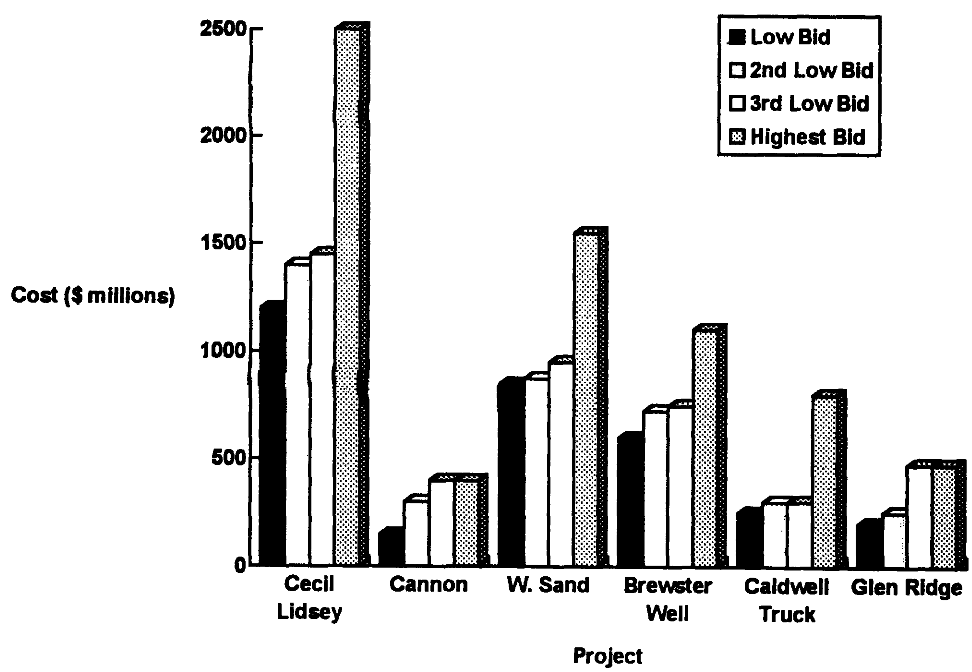
This section points out the problems the EPA has had in using the lump-sum method for remedial contracts. The bids they receive to do work usually vary tremendously. In 1990, the Hazardous Site Control Division of the EPA and the company CH2M Hill developed a database of bids that were received for Remedial

[38]Fite, Mark J. P. 418.

Actions at federal-lead Superfund sites.[39] The database contained entries for 52 sites with actual completion costs for 25 of the sites.

Figure 4-1 shows the large spread of the bids received for six of the projects. For the twenty-five sites analyzed, the highest bid was generally much larger than the next most expensive bid, while the low bid was fairly close to the second and third lowest bid. The average ratio of high bid to low bid was 1.7 to 1 and the largest ratio was 4.6 to 1.[40] The importance of this data is that it shows the difficulty that contractors have in winning competitively-bid contracts. The contractors' bids are spread throughout a wide range on almost every project in the study. The contractor that won must have made different assumptions than the one that bid much higher. Often, these assumptions can present tremendous risks to the succesful contractor once the contract has been awarded.

Figure 4-1. Bids Received for Superfund RAs
Source: US EPA Hazardous Site Control Division and CH2M Hill, 1991



[39]The data for this analysis was presented by Kenneth Ayers of the EPA and Amy Halloran and Dikran Kashkashian of CH2M Hill at the Hazardous Waste Conference in Dallas, Texas, May 1, 1991.
[40]*Ibid.*

This study also showed the problems that occur for lump-sum contracts once the contract has been awarded. The managers on the sites have a difficult time managing because the contract is based on information provided by a study and design that may not be entirely correct. As a result, once the remediation begins, the project managers may discover inaccuracies in the design, and therefore must begin submitting change orders in order to get paid for the different work. This process takes time and usually results in disputes between the owner and the contractor. But this path is the only one the contractor has in order to manage the uncertain nature of the remediation project. For the 25 sites in the database, the award bids underestimated the actual costs by 7 percent. The contractors used change orders to adjust the contract, and the change orders had a range of -$1.5 million to $5.0 million for a total of $13.3 million on all 25 sites, including four sites on which there were negative change orders.

The lump sum contract is only effective when the work is well-defined and the risks of discovering problems on the site are lower. Of course, the more competent the contractor, the more able he may be to accept these risks and achieve higher profits. Clients may want to transfer the risk of the project to a contractor, so a competent contractor could win work if he is willing to assume the risks.

4.1.2. Reimbursable Contracts

In the 1990's, perhaps the most widely used contract is some type of reimbursable, or cost-plus, contract. This type of contract recognizes that some work is difficult to quantify, and therefore a contractor is paid for the actual worked performed. He then receives a percentage of the cost as a fee or profit. The section will analyze the three different types of reimbursable contracts used on remediation projects: cost plus a fee, cost-plus a fixed fee, and cost-plus an award (incentive) fee.

Cost Plus a Fee

This contract is one in which the contractor receives a percentage of the costs of the project for a fee. These contracts are used on sites where there is in undetermined amount of work and the owner pays for the costs of the project. This method is not often used because it creates a perverse incentive for the contractor: the higher the cost of the project, the higher the fee. As a result, the contractor does not want to contain the costs of the project, but instead wants to escalate the costs. In typical construction, this is managed by having a guaranteed maximum price (GMP) on the project, but the risks in remediation make this concept difficult to use. This method was used in the late 1980's as a substitute for lump-sum contracts on complex and difficult sites, however the perverse incentives have caused it to be used rarely in remediation.

Cost Plus Fixed Fee

The *Environmental Business Journal* recently claimed that fixed fee contracts will become the most widely used contracts in remediation: Remediation will evolve towards more fixed fee contracts as cleanup results and performance, rather than billable hours become the focus."[41] The fee is determined as a percentage, usually between 6 and 9%, of the overall original estimated cost of the project. This type of contract is appropriate when the uncertainties that make it necessary to contract on a cost-reimbursable basis are so great that establishment of predetermined targets and incentive sharing arrangements could result in a final fee amount inconsistent with the actual quality of a contractor's performance.[42] The fee is set prior to the commencement of work, and does not change if there are overruns or underruns on the project.

The estimate is extremely important here for both the contractor and the owner. Both sides must agree to an acceptable estimate to base the fee on. Then, regardless of the final cost of the project, the contractor will receive only that fee. The incentive, then, is for the contractor to finish the project under budget to increase the margin on the job. If the costs run over, then the margins will lower. Careful oversight by the owner is warranted, though, because there is not a large incentive to control costs since the fee is fixed.

These contracts appear to be effective in managing the risks involved in remediation. It forces both the owner and the contractor to appropriately characterize the work. The contractor, though, still can raise the fee by submitting changes to the scope of the project, so a relationship can develop between the owner and the contractor which is similar to that found in a lump-sum contract.

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[41] "Contract Flexibility", p. 5.

[42] USACE (New England Division) TERC Delivery Order Seminar, p.31.

Cost Plus Award (Incentive) Fee

These contracts have been widely used by the EPA and the Department of Defense over the last five years. The EPA's contracts were termed Alternate Remediation Contract Strategy (ARCS) in 1990. This type of contract is reimbursable, and the fee can total up to 10% of the contract value. This fee is comprised of a base fee portion and an award fee portion. The base fee does not vary with the quality of performance. The contract attempts to compensate the contractor for risks and allows for costs incurred not normally accommodated under standard government contracts, such as financing costs.[43] The award fee is available whenever the contractor achieves high-quality performance based on the owner's evaluation of the work. This evaluation is based primarily on cost and schedule goals, and it also can include other factors such as safety record, achieving affirmative action goals, or other measures the owner feels are important to the outcome of the project.

In order to administer this type of contract, the owner must develop a formal performance evaluation procedure. This has presented considerable challenges to the EPA and the Department of Defense in the administration of these contracts. Mike McKenzie, a project manager for the Air Force, is overseeing the cleanup of Pease Air Force Base in New Hampshire. Almost all of the contracts have been award fee contracts. He describes them this way: "We have no feedback yet on the effectiveness; however, it appears to be labor intensive for the Air Force as we will be required to do a performance rating quarterly on a system developed by the contracting section."[44]

In addition to an intense evaluation effort by the owner's representatives, the contractors also submit a self-evaluation for inclusion in the evaluation package. These contractor "self-evaluations" are often lengthy and quite detailed; obviously, the contractor wants the award. But, the owner pays for the contractor to perform the self-evaluation, so the entire process can become extremely expensive for the owner.

Another important aspect of the award fee contract is the criteria that the award is based on. Originally, in most of these contracts, performance was evaluated for every work assignment, or task, in a given time period. The evaluation was usually based on

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[43]*Superfund Revitalization: Measures of Success*. p. 49.
[44]Interview with Mike McKenzie, January 19, 1995.

whether or not the work was performed on time and to standard. Interestingly, cost control was only factored into the task evaluation and was not a stand alone evaluation. As a result, contractors often attempted to manipulate their schedules and disguise the true costs, explaining it all in a lengthy "self-evaluation".

The EPA has recently changed its criteria for the award fee process. Now, the contracts include greater performance incentives with fewer administration requirements.[45] There are now greater incentives available, but only for work that exceeds the EPA's expectations. For a contractor, this means that there must be a strong relationship with the owner in order to ensure that the award fee system is clearly understood.

4.1.3. Indefinite-Delivery Contracts

Indefinite-delivery contracts are becoming extremely popular for both public and private clients. The purpose of this type of contract is to speed up the remediation process by having a pre-placed contract with a qualified company to perform work as it is encountered. This is particularly helpful for government agencies who now do not have to go through the traditional and time consuming procurement methods in order to obtain services.

According to the Army Corps of Engineers, there are three types of indefinite-delivery contracts:

- **Definite-Quantity/Indefinite-Time Contract**:
    1. Provides for the delivery of a definite quantity of specific supplies or services.
    2. What is indefinite about this type of contract is the time for delivery. The time for this type of contract is indefinite, the quantity of supplies or services is not.
- **Requirements Contract**:
    1. Provides for the filling of all actual requirements of designated activities for specific supplies or services during a specified contracting period, with deliveries to be scheduled by placing orders with the contractor.

[45]*Superfund Revitalization: Measures of Success.* p. 49.

2. Both quantities and the time for delivery are indefinite. A contracting officer must state realistic estimates of quantities in a solicitation for a contract, but this estimate is not a guarantee that the estimate will be required.

- **Indefinite-Quantity Contract**:
  1. Provides for an indefinite quantity, within some limits, of supplies or services during a fixed period
  2. The client must order at least a stated minimum of supplies and services not to exceed the maximum established in the contract

4.1.4. Client Service Agreements

Many clients today are hiring remediation companies through pre-placed client service agreements in order to ensure that they can receive remediation services when needed on an emergency or planned basis. These agreements allow for pre-negotiated rates, terms, conditions, and requirements for a specific company. For example, a company that produces a certain type of chemical waste can have a pre-placed contract with a contractor. This contractor can already have identified the remedy type and approximate cost for different spills in the event of a spill or a discovery.

4.2. Pre-Construction: Cost Estimating

Cost estimating gives a approximation of what the final price of the project will be. This section outlines the estimates that are performed on remediation projects throughout all phases, then it shows the inaccuracies of estimates through data collected by the EPA , and finally it explains what contractors are doing in order to effectively estimate the costs of a project.

4.2.1. Estimates on a Project

During the life of a project, cost estimates are usually prepared at least four different times:[46]

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[46]Duvel, William A. "Controlling Environmental Cleanup Costs". *Hazardous Materials Control*. Volume 5, NO. 2, March/April 1992, page 35.

1. Initial estimates are made following the preliminary investigation. These are often wild guesses and have no substantive basis. They are performed by consultants or engineers who have little hard construction or remediation experience, and they are based on data that is most likely incomplete. Unfortunately, most clients latch on to these initial estimates and expect a contractor years later to be able to conform to them.
2. The second estimate is usually done at the conclusion of the Feasibility Study on Superfund projects (This is the end of a detailed investigation and assessment for non-Superfund projects.). Here, the engineers developing these estimates are making an honest effort to reflect real-world costs, but the time necessary to establish them and the level of design detail available is often inadequate to provide a very detailed basis for the estimate.[47] This is no more than a "ball park estimate", and the EPA target range is +50/-30%.
3. The next estimate is developed at the conclusion of the detailed design stage. At this point, the engineers believe they have a clear idea of what is necessary and what all the components of the work will be.[48] However, they may lack the construction experience to make an accurate estimate, and there may be little data available on the type of cleanup because it has been used infrequently. The EPA target range for these estimates is +15/-5%.
4. The final distinct estimate of the cost occurs when the bids come in from the cleanup contractors. These bids are usually the most accurate because the contractor is committing to do the work, but the bottom line total remains uncertain because of the unknown quantities and conditions.

In addition to these estimates, the owners or other interested parties may conduct their own estimate based on data they collected themselves to use as leverage in disputes with other parties involved on the project. For example, a community group may try to show that a certain remedy is more expensive than the government is estimating in order to prevent the remedy from being selected.

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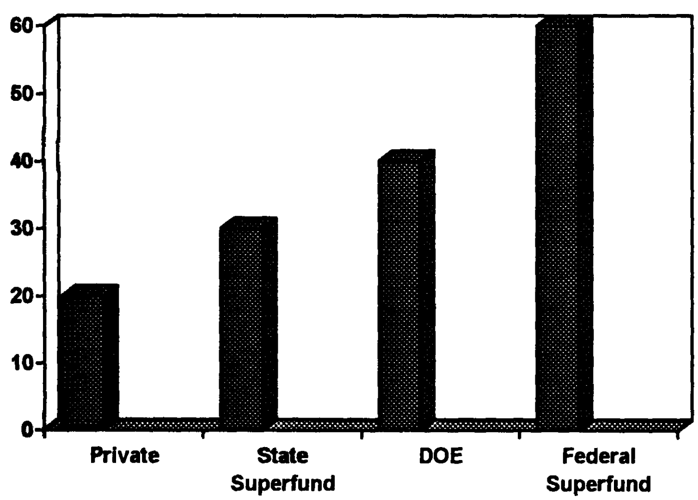
[47] *Ibid.*
[48] *Ibid.*

4.2.2. A Study on Estimates Performed on Superfund Projects

A study in 1992 of 51 completed remedial actions showed costs can be underestimated by as much as 53% and overestimated by as much as 250% from the initial estimates.[49] While Federal Superfund projects produced the most inaccurate estimates, all remedial action projects showed significant growth from the initial estimates: Figure 4-2 shows the average cost growth from the initial estimate for projects led by different agencies.

Figure 4-2. Average Cost Growth
Source: Brett R. Schroder, Independant Project Analysis, 1992



As indicated in the figure, while all agencies strive to obtain accurate estimates, it is alarming to see the wide range in deviations of actual costs from estimates.[50] While high cost growth can be accounted for with the use of an adjustment factor, the large variability in cost growth is much more difficult to resolve.[51]

The following is another example of the inaccuracies in estimating. This data was collected by the Hazardous Site Control Division of the EPA in the same study that was mentioned earlier in this chapter. There are 19 completed Superfund projects on

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[49] Schroeder, Brett R. "Cost Inaccuracies in Superfund Projects: Strategies for Building Better Estimates". Paper presented at the Superfund Conference, November, 1992.
[50] *Ibid.*
[51] *Ibid.*

which to analyze the accuracy of the estimates. This study examined whether or not the different estimates that were performed were accurate compared to the actual RA costs.

Table 4-2. Estimating Accuracy vs. Actual RA Costs[52]
Source: US EPA Hazardous Site Control Division and CH2M Hill, 1991
*** Note: A "-" sign indicates that the estimate was lower than the actual cost, while a positive value indicates that the estimate was above the actual cost.**

Technology	Site	Accuracy of ROD Estimate (%)	Accuracy of Engineer's Estimate (%)	Accuracy of Award Bid (%)
Alternative Drinking Water Supply	Western Sand	42	8	-10
	Caldwell Trucking	10	-5	-18
	Blosenki Landfill	46	-33	-30
	Odessa 1	46	46	-16
	Odessa 2	22	22	-12
Soil Treatment/ Landfilling	Lang Property	-38	9	-5
	Metaltec	-12	5	3
	Lake Sandy Joe	60	-11	-10
	Old Mill	-19	18	-10
	Bioecology Systems	-53	10	-30
	Crystal City	30	-11	-9
	Cecil Lindsley	48	13	unavailable
	Petrochemical Systems	-54	20	-4
	United Chrome	17	-40	-45
Water Treatment	Vestal Water Supply	-55	31	-2
	New Lyme Landfill	-28	-20	-10
	Old Mill	-29	18	-8
	Bioecology Systems	-19	10	-25
	Geneva Industries	-53	7	-25

The following conclusions can be drawn from this table:

[52]The data for this table was taken from the study by Ayers, Halloran, and Kashkashian.

- All of the ROD estimates for providing an alternate water drinking supply overestimated the actual RA costs
- Less than half of the engineer's cost estimates are within the EPA's target range of +15/-5 % of the actual RA costs, although the average difference is only 2%.[53]
- The majority of the ROD estimates are within +50/-30 percent (the EPA's standard) of the actual cost of the RA. However, this goal does not appear to be too ambitious.
- The award bids are generally more accurate than either of the other two estimates. This could lead to the conclusion that the contractors do a better job than the designers and the assessment team in providing accurate cost estimates.
- The award bid was usually lower than the actual cost. This is expected because the contractors need to make favorable assumptions in the preparation of the bid, otherwise they will not get the award.
- The data shows numbers that are all over the place. This shows the general problems with estimating remediation work at any level.

The estimating methods used for these projects, then, did not appropriately take into account the unique issues that remediation projects pose. The unknown and unique conditions of sites have rendered the existing estimating methods inadequate.

4.2.3. Managing Remediation Estimating

The studies from the previous section demonstrate the difficulty owners and contractors have in managing cost estimates. For the contractor that is competing for work on a competitively bid lump sum basis, the following are recommendations for managing cost estimating:

- Be careful with lump sum bidding for complex remediation projects. If it is mandated by the government, then the contractor should use a unit price for the quantities that are indefinite.
- If the work is competitively bid on a lump sum basis, make favorable assumptions when preparing the estimate in order to be awarded the contract. This means that the estimator must assume that the conditions are as they appear in the plans, and must consider minimally the chance that these will escalate. If and when they do, the

[53] *Ibid.*

contractor must ensure that he has a firm grasp of the change clauses in the contract (This is covered in the next section.). This is the only way to get the work!

- A contractor should not be responsible for the performance of innovative technology imposed on it by the government. Many of the RODs dictate what equipment the contractor must use for the remediation. Often the equipment has not been proven, so the contractor should not take on the risk when preparing an estimate.
- Base your estimate on your own data and trusted information whenever possible. A contractor faces increased risk if it relies entirely on the information provided by the designing engineer. Therefore, a good contractor will have the capability to perform its own assessments of the data and the design before preparing the estimate.
- Carefully identify and analyze the issues of remediation projects that were described in the last chapter. These are items that can drastically change the cost of the project, so understanding them is critical to developing an accurate estimate.

As clients turn to contractors for solutions to contaminated sites, they will want to use lump sum or fixed fee contracts to force the contractor to achieve a high level of quality on the job. The contractor, then, will have to develop accurate cost estimates to avoid the problems of cost overruns during remediation.

4.3. Pre-Construction: Scheduling

There are many similarities between cost estimating and scheduling, or time estimating. Scheduling presents contractors with the same dilemma that they have for cost estimating: there most likely will be delays, but how do you account for these delays when the client demands to know when the project will be completed?

Scheduling is another aspect of project management that is extremely affected by the characteristics of remediation. Just as in cost estimating, contractors have a difficult time determining an accurate schedule of activities. Scheduling, though, is not as important during the assessment and the design phases because there is often little financial gain from an owner finishing the project early. As a result, contractors are the first group that will attempt to make a detailed schedule.

The following issues affect the ability to produce a schedule:

- Remediations are not often complex (few tasks)

- There may not be sufficient data available to form an accurate benchmark for the work. If the contractor and the owner are unfamiliar with the remedy technology or method, then it may be difficult to determine how long it should take.
- Many of the tasks are purely construction, with no contamination
- Some tasks could have large unknowns due to nature of contamination
- Owners are more willing to offer additional time for a delay in the project as opposed to offering additional money

As a result of these points the following conclusions can be drawn about preparing a schedule during pre-construction:

- The most important element in developing an effective schedule for a remediation project is to determine what tasks in the project are easily defined and assess how long it will take to perform them; and to identify the work items that are difficult to determine how long they will take. Usually, this means identifying the hazardous work from the non-hazardous work. Then, a contractor can organize the project into a Work Breakdown Structure, or a "family tree" of components that define the total scope of the project. The components of the project that are difficult to define should be grouped together so that they can be properly monitored throughout the project.
- The contractor must use a scheduling software package that can easily change the schedule and update as necessary. Some projects that have few tasks to complete do not require the use of an expensive or complex software package. The following table outlines a guide to the different scheduling tools used on projects:

Table 4-3. Project Scheduling Tools[54]
Source: Camp Dresser & McKee, 1995

Product	Advantages	Disadvantages	Considerations
Manual	• Helps you think through project • User friendly • Price • Access widespread	• No updates or controls • No graphics	• Size of project • PM knowledge - Earned Value - Managing Scope -"What if" scenarios
Low End Software <$1,000	• Helps you think through project • User friendly • Price • Updates and controls	• Limited Graphics • No real independent review • Experience required to identify tasks	- Resource allocation • Progress reporting requirements • Client sophistication • Importance to control: - Lots of risk
High End Software >$1,000	• Helps you think through the project • Less PM knowledge required • Graphics/Reports • Independent review • Updates and controls	• Price • Maintenance costs • Specialized staff • Limited access • Perception of cost to update monitor	- Tight budget - Change request process

- On remediation projects, there is a tremendous need to change the schedule based on events in the field. As a result, it is a necessecity to use some type of computerized system so that the schedule can be changed easily. Although many remediation projects involve few tasks, it is still imperative to use the computer-based system so that changes can be made
- The contractor must interact with the designer and the owner in order to inform them of the areas identified that could cause delays. Too often owners receive an initial schedule and expect that to be followed. An effective contractor should inform the client of the components of the project which will have durations that are difficult to predict. This leads to the next important portion of pre-construction: Player Interaction.

[54]Fairneny, Christine. "Project Management Tools for Hazardous Waste Site Investigations." Notes from presentation on April 28, 1995.

4.4. Pre-Construction: Owner/Designer/Contractor Interaction

The discussion of the contracts, the cost estimating and the schedule planning leads to the conclusion that it is imperative that a contractor find effective ways to interact with both the owner and the designer. In a standard construction process, a designer and contractor have little need to interact, while an owner's involvement is often limited to interacting with the designer. Remediation calls for something different. The previous sections all indicate that a project is not simply a matter of reading designs and specifications and executing the work. Instead, the contractor needs to meet with the designer, the owner, and the assessment team in order to identify the risks in the project and ensure that all elements of uncertainty in the project are fully understood.

One method that has emerged to manage these interactions has been the use of partnering. Partnering is a process which promotes teamwork and minimizes confrontation. On large construction projects such as the construction of the Central Artery/Third Harbor Tunnel in Boston, partnering is being used successfully on all construction contracts. Given the uncertain nature of remediation work, a partnering philosophy is imperative in order to maintain an effective relationship throughout a project. A partnering agreement states that all parties agree to interact in a professional manner and resolve disputes expeditiously and professionally. A contractor should encourage the client to use a partnering agreement between the consultants, designers, and contractor, and whoever else has a significant role in the remediation process.

4.5. Construction/Remediation

Once a contractor begins the remediation, he must develop a system to manage the complexities and uncertainties that are often experienced on projects. This section addresses methods to track the cost and schedule, how to manage the changes once they do occur, and how the contractor can interact with the owner in order to move expeditiously on the project.

4.5.1. Cost and Schedule Control

A successful contractor must employ some project management tracking system. Jay Gooch, Senior Project Manager for OHM Remediaiton, says that it is difficult to track a project because it is difficult to see progress. He claims, "A site usually looks the same at the end as it did in the beginning."[55] As a result, it is often difficult to track performance of the project to ensure that it is being run most efficiently.

Camp Dresser & McKee, a leading environmental assessment and design firm for the past decade also supervises the remediation of contaminated sites. They have recognized the importance of tracking progress on remediation work, whether it be in performing assessment services or supervising the actual cleanup. They perform the following steps to monitor project progress:

- Frequently update schedule and actual cost through a manual system or a software program
- Identify variances from the plan
- Evaluate the impact to schedule
- Evaluate the impact to resources
- Evaluate the impact to budget

An important element for CDM is to use the concept of "Earned Value". Earned value is a method for measuring project performance. It compares the amount of work that was planned with what was actually accomplished to determine if cost and schedule are progressing as expected. The earned value is calculated as follows:

Earned value = % physically complete x Budget for that task

The budget can be expressed as either hours or dollars to track both schedule and cost progress. This system is excellent in maintaining an accurate picture of how the remediation is progressing. The following example demonstrates the effectiveness of this type of system.

Cost and Schedule Control Example

The following is an example of cost and schedule tracking for one component of a remediation project. There are five tasks that make up the overall task of soil remediation. At any given time in the project, a manager can input values for the physical progress to date. This generates an earned value which can be compared to the actual dollars or weeks spent to date.

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[55]Interview with Jay Gooch, May 17, 1995.

Table 4-3. Cost Forecast

Source: Christine Fairneny, Camp Dresser & McKee, 1995

Task	Activities	Physical Progress	Budget Dollars	Earned Dollars	Actual Dollars	Estimate to Complete	Forecast	Variance
1	Mobilization	100%	10,000	10,000	12,000	0	12,000	2,000
2	Monitoring well installation	100%	23,000	23,000	22,000	0	22,000	-1,000
3	Soil Sampling	80%	5,000	4,000	6,000	2,000	8,000	3,000
4	Excavation and capping	40%	1.7 mil.	680,000	800,000	1.2 mil.	2.0 mil	300,000
5	Construction of soil treatment facility	20%	2.6 mil.	520,000	500,000	2.0 mil	2.5 mil	-100,000
	Task Totals	28%	4.38 mil.	1.24 mil.	1.34 mil.	3.2 mil.	4.5 mil	204,000

Table 4-4. Time Forecast

Source: Christine Fairneny, Camp Dresser & McKee, 1995

Task	Activities	Physical Progress	Budget Weeks	Earned Weeks	Actual Weeks	Estimate to Complete	Forecast	Variance
1	Mobilization	100%	2	2	2	0	2	0
2	Monitoring well installation	100%	3	3	3	0	3	0
3	Soil Sampling	80%	1	.8	2	1	3	2
4	Excavation and capping	40%	20	8	10	12	22	2
5	Construction of soil treatment facility	20%	30	6	8	24	32	2

It is important to understand that the physical progress and the estimate to complete is not necessarily based on a percentage of money or time spent on the project. Rather, it is based on the experience and knowledge of the project manager who needs to make an honest evaluation of the progress. The manger, therefore, must be competent and not have any perverse incentives for adjusting the values of the estimates.

4.5.2. Change Management

During the construction, the contractor needs to understand how to manage changes on the project. Normally, changes are managed by requesting change orders from the owner for either more (or less) money and/or time. Overall, a contractor needs to ensure that there are mechanisms in place with the owner that will allow for timely and equitable changes.

The change mechanisms all came from traditional construction projects. Unfortunately, these mechanisms alone are somewhat inadequate to deal with the nature of remediation. Table 4-4 shows the different clauses and their significance to the contractor.

Table 4-6. Changes Clauses to Remediation Contracts
Source: Theodore Trauner and J.Scott Lowe, 1991

Type of Change/ Clause	Description	Comments
Directed	• Occurs when the owner desires something to be added to the work which was not originally specified	• Usually occurs if the site has not been sufficiently characterized • Owner can avoid the necessity of these by clearly specifying the work in the contract documents
Constructive	• Created by the owner's actions or lack of actions	• When used by a contractor, this is an indication of a difficult relationship; this is a finger-pointing solution • Often caused by lack of experience by the owner and the contractor
Differing Site Conditions	• Type I: Occurs because what actually exists at the site differs materially for the representations made in the contract documents • Type II: Occurs when material is discovered which is unusual or unexpected and would not normally be anticipated for that type of work in that location	• Very common in remediation • Creates numerous claims and disputes as the parties all contest whether or not a site is actually "differing" • Type II: Unusual in remediation because almost anything can be expected or reasonably anticipated

(Table 4-6 cont)

Type of Change/ Clause	**Description**	**Comments**
Errors and Omissions	• Occurs from a mistake in the contract documents made by the design engineer	• Designs often are not good representations of what is actually in the ground, and so omissions are not rare • These lead to disputes between the owner, designer, and the contractor, but the contractor usually would have paid for the work anyway

All of these changes can lead to significant delays and cost changes. Many of these problems can be avoided if the owner and the contractor would develop and maintain a strong working relationship. Unfortunately however, because of the cultural barriers and the inflexible contracting mechanisms, painful relationships often develop.

Example of a Remediation Dispute[56]

The following is an example of a typical dispute that held up a remediation project for months. During a soil remediation project, the contractor encountered hazardous wastes on a haul road to the site. The contract documents represented that no hazardous materials were anticipated on this road. As a result of this differing site condition, the contractor had to construct a new haul road for the majority of the excavation work. This caused the distance for hauling soil off the site to increase considerably, which caused the soil removal to take longer than anticipated. The owner vehemently fought with the contractor over whether or not the changes were do to a differing site condition or the contractor should have identified this problem in the pre-bid process. Also, the owner did not maintain good records on the excavation, so the contractor used this to benefit as much as possible from the changes.

[56]*Ibid.*

Effective Change Management

This section outlines some important methods a contractor can use to minimize disputes on remediation projects. The following are key recommendations:

1. Have the capability to review the contract plans and specifications to determine the potential risks involved in the project. Do not rely on the data and design from the assessment team or the designer. If the owner did not perform a detailed site investigation, then simply stay away from the project! A contract with a miserly owner during the assessment stage probably will have numerous changes and problems once the construction begins.[57]
2. Understand the change clauses in the contract, and ensure that the contract is worded so that the owner and contractor have the ability to make timely changes when necessary. The following table describes clauses that can be put into a contract in order to minimize disputes:

Table 4-7. Minimizing Changes with Clauses
Source: Theodore Trauner and J.Scott Lowe, 1991

Clause	Description	Effect
If and Where Clauses	Clauses that stipulate work that the owner may want to perform but is undecided if it will be necessary	• Reduces that problems with "owner directed" changes • It anticipates the changes that my occur so that the contractor has already provided an estimate for the work • Manages many of the Differing Site Conditions changes

[57]Lowe, J. Scott and Theodore J. Trauner, Jr. "Construction Disputes on Hazardous Waste Projects". Hazardous Waste Conference, May 1 and 2, 1991, p. 566.

(Table 4-7 cont)

Clause	Description	Effect
Alternates or Adds	Clauses that go beyond the base contract when the owner is undecided as to which method will be the best until after the project begins	• Owner can bid the project and begin work before deciding on a final method • Owner is not obligated to award the execution of the work • Contractor already has estimated the work which avoids disputes during the project • Should not tie the "adds" together; executing one add should not lead to the necessary execution of other adds
Variations on Estimated Quantities Clauses	Allows for a contract adjustment for overruns or underruns when it is difficult to determine the exact quantity of the work	• Allows for easy changes to the contract price if the estimates on the quantities is significantly inaccurate • It recognizes the nature of the work - there are indeed portions that are difficult to define
Allowable Costs for Delays	Specifications on the contract on how the owner will reimburse the contractor if there are delays	• It prevents disputes and litigation over whether or not a contractor should be compensated in the event of an unforeseen delay

In addition to these two methods to manage changes, contractors should also implement a quality control plan for the site, and it should consider effective methods to interact with the owner and designer. The next two sections will describe QC and interaction on remediation projects.

4.5.3. Contractor Quality Control

A contractor Quality Control (QC) Plan is an important element of a successful remediation project just as it is in non-hazardous construction. The Army Corps of Engineers defines quality control as the mechanism by which the contractor ensures the end product complies with governing regulations and the contract requirements.[58] The

[58]Request for Proposals for the Total Environmental Restoration Contract. U.S. Army Corps of engineers New England Division, August 8, 1993, p. C-15.

contractor must develop a QC organization and a set of plans and procedures to ensure that effective remediation takes place. The toxic nature of some components of the remediation project provides the contractor with additional challenges to managing quality. The following is a description of those challenges:

- The importance of the sampling and collection of data. The purpose of the project is to clean up a site, so it is critical to track a project to determine how clean it has become. The detailed sampling and analysis of data is a subject that is beyond the context of this paper, but the contractor must understand that he must maintain a high standard of quality for data sampling. Perhaps the entire project depends on the results of this data.
- The difficulty of managing while working in full-protective gear. Workers and supervisors can become lethargic and overlook the quality aspects of the work when they are in protective gear for an extended length of time.
- The challenge of ensuring quality on a project where it is difficult to measure results. It has been mentioned earlier that remediaiton is often difficult to control because it is not easy to see the results. This is true for the control of quality as well.

Given the challenges mentioned above, a contractor must develop both a Quality Control Plan and a Data Quality Control Plan. The quality control plan should be similar to that found in construction. The Data Quality Control Plan is critical and must include the following:

Sampling and analysis data quality objectives
The sampling and analysis organizations
The qualifications of the chemical support staff
Sampling procedures
Handling, labeling, and shipping procedures
Chain of custody procedures
Calibration of analytical equipment
Data analysis and reporting

The quality control personnel must be trained properly to inspect a project. They should receive additional training on management in a contaminated area, and they should not spend long periods of time in protective clothing. Also, the QC plan should identify areas that may cause problems in the quality control and work with the owner to identify these problems before they occur.

While the contractor must perform his own Quality Control, the owner will also perform some type of Quality Assurance (QA) that inspects the performance of the QC Plan. The QA plan can involve oversight of the contractor's personnel, and also sampling by a third party to confirm the results of the data obtained from the QC Plan.

4.5.4. Owner/Designer/Contractor Interaction

Interaction between the contractor and the owner is critical during the construction or remediation just as it was during the pre-construction. The partnering concept is a perfect fit for the type of interaction that must take place during remediation. The section on cost and schedule control and change management show that the contractor must work together with the owner to ensure efficient execution of the remediation. The next chapter provides a better view of partnering in a case analysis of a Superfund site.

4.6. Post Construction: Documentation and Evaluation

The most critical portion of a remediation project is the end when the contractor thinks that the work specified in the contract is complete. The issue of "How clean is clean?" has been debated over the years, but what is important to the contractor is to get off the site with the acceptance of the regulatory agencies.

The EPA requires detailed reports for any work performed on a remediation site. Although the final reports are ultimately the responsibility of the owner and not the contractor, the contractor must participate in this process in order to ensure completion at the site. The EPA publication "Superfund Remedial Design and Remedial Guidance" requires the following elements in the post remedial action reports:

- "Brief description of outstanding construction items from the prefinal inspection and an indication that the items were resolved
- Synopsis of the work performed and certification that this work was performed
- Explanation of any modifications to work and why these were necessary for the project

- Certification that the remedy is operational and functional
- Documentation necessary to support deletion of the site from the NPL
- For a responsible party RA, the document of settlement may specify different final inspection/certification conditions"[59]

Certainly, the EPA or any regulatory agency is going to be extremely careful before it declares a site done. Therefore, the contractor and the owner must understand what documentation they need to provide in order to complete a site documentation report. The following steps are recommended for a contractor to follow in order to ensure successful documentation:

- Address the documentation issue with the owner prior to signing the contract. If possible, assign responsibilities for the documentation in the contract itself.
- Maintain accurate records of construction activities. Historical documentation is important to document quantities excavated, cleanup levels attained, and materials and equipment used.[60]
- Maintain accurate information for long-term performance monitoring and site maintenance. Also report any information necessary for the repair or modification in case of failure.
- Capture field data applicable to future projects. This is particularly important in developing new technologies and assessing the effectiveness of existing technologies. In this industry, possessing actual data can be valuable.
- Maintain lessons learned on each project. This again is invaluable to the future projects in remediation.

Although the responsibility for these reports usually falls on the owner and the designer, contractors should still understand that remediation sites will be inspected by the EPA at least once every five years after the remediation begins. Therefore, if anything ever goes wrong on the site, the contractor needs to have the information on each site in order to defend his actions.

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[59]Facklam, Heidi L. "HTW Construction Documentation Report: A Necessary Element in a Successful Remediation." Hazardous Waste Conference, May 1 and 2, 1991.
[60]*Ibid.*

4.7 Summary

This chapter has shown that the traditional roles and functions of the contractor need to be adjusted in order to manage the hazardous waste remediation project. The next chapter examines some of these issues on an EPA Superfund Site in Norwood, MA administered by the Army Corps of Engineers and remediated by Foster Wheeler.

CHAPTER 5

THE TOTAL ENVIRONMENTAL RESTORATION CONTRACT AND THE NORWOOD PCB SUPERFUND SITE

5.0. Overview

The United States Army Corps of Engineers has long been referred to as the "Nation's engineers". It has the responsibilities for managing the waterways of the U.S. and is responsible for construction on Army installations. It has also taken on the role as the responsibility of administering numerous hazardous waste remediation projects throughout the United States. Particularly with the military downsizing and bases closing, its construction has decreased while its cleanup of closing installations increased. This chapter examines the innovative methods the Army Corps uses to carry out a remediation project, and it shows these methods in action on a project in Norwood, MA.

5.1. The Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) currently assists many Federal agencies in the execution of their environmental cleanup programs. These agencies include the Department of Defense, the EPA, the Department of Energy, the General Services Administration, the Federal Aviation Administration and the Department of Commerce. The Corps is in an excellent position to administer these projects because of its vast construction experience and its experience in managing it own hazardous and toxic waste program.

Initially, the Army Corps performed remediation work using the standard two contract approach: one design contract issued under the Brooks Act procedures followed by a fixed price competitive construction contract issued to the low bidder.[61] In more than ten years of managing projects, it developed the following list of issues that rendered this method inadequate:

61."Missouri River Division Acquisition Plan," p. 2.

- The consistency, retention of knowledge, responsibility for liability and project familiarity provided by the use of a single contractor through all phases of the project have been extremely critical to the efficient, cost effective and timely completion of some projects.
- Implementation of uncertain or innovative technologies on sites that have difficult-to-define characteristics make it almost impossible to clearly define remediation requirements. This makes it extremely difficult to define the requirements for contractors bidding on a project.
- Time is often a critical factor in preparing to clean up a site due to the hazards that exist to human health.
- Site characterizations can only be taken so far. Experience has shown that once a certain point is reached, site investigations become more expensive while producing little or no additional benefit. Making one contractor responsible and accountable outweighs the possible conflict of interest that may arise when the same entity investigates and remediates.
- On large sites, the Corps has learned that it is necessary to start different phases of the remediation process at the same time. For example, point sources of contamination may be identified while conducting preliminary investigations that require an immediate cleanup while the investigation into the site continues. This places at least two contractors at the same site with overlapping responsibilities. These conditions create an overlap of work forces, contract administration, and management teams that make a cost-effective remediation difficult to accomplish.

5.2. The Development of the Total Environmental Restoration Contract (TERC)

These conditions prompted people in the Corps to look for better ways to administer remediation work. One place where there was an intense effort to look for a better method was in the Tulsa, Oklahoma District of the Missouri River Division of the Corps. Here, there was pressure to comply with a Congressional mandate ordering that a number of Superfund projects must start actual cleanup by October 1989. This mandate was in response to intensifying public frustration with what was perceived as the relatively few number of hazardous waste site cleanups, especially Superfund sites, that had been actually accomplished.[62] The Omaha District formed a partnership with the Air Combat Command (ACC) of the U.S. Air Force, which was under pressure to execute its aggressive Accelerated Cleanup Program (ACP).

The Contracting Division Chief of the Omaha District, Don Robinson, and the Chief of the ACC's Environmental Restoration Division, Bob Moore, led the charge to find a new way to get cleanups moving. Mr. Moore explains their goals this way: "We started with a blank sheet of paper. We asked, 'If we could execute a program in the most efficient way possible, how would we do it?'"[63] Mr. Robinson adds, "We had as our goal adding much greater flexibility to the complex cleanup contracting process. Our ultimate goal was to speed up the actual removal of hazardous waste, as opposed to studying it to death."[64] The result was a mechanism that looked at an installation or a large site "fence to fence" rather than project by project, and it did it from the perspective of a single contract. This mechanism was called the Total Environmental Restoration Contract, or TERC.

5.2.1. The TERC

The TERC is a flexible environmental response contract that permits a single contractor to provide full Hazardous, Toxic, and Radioactive Waste cleanup services at an installation or in an area through Indefinite Quantity/Indefinite Delivery Contracts with Cost Reimbursable Delivery Orders for various Corps customers.[65] It wraps an entire cleanup process into a single contract with one contractor providing study-to-remediation activities at the site. The TERC awards a single contract with a value targeted near $200 million for a period of four years with two additional three-year options. The contractor is guaranteed a minimum amount of work around 20% of the maximum contract value.

The owner is then assured of having a preplaced contractor responsible to coordinate and supervise remediation work anywhere within a certain region. Projects

[62]Erickson, Stu. "TERC Adds Weapon to Contracting Arsenal." *Omaha District Quarterly*, Summer, 1993, Volume 17, No. 3, p. 7.
[63]Erickson, Stu. "District Issues Four TERCs Totaling $650 Million." *Omaha District Quarterly*, Winter 1994, Volume 18, No. 1, p. 15.
[64]Erickson, "TERC Adds Weapon...", p. 7.
[65]Pollis, Gerard. "Information Paper: Total Environmental Restoration Contracts", Jan 25, 1995, p. 1.

requiring support from the TERC must display at least several of the following characteristics:

- Made up of two or more sites
- Conditions indicate a high probability that interim remediation of point sources of contamination will be required
- Pre-remediation and remediation activity requires significant interface and coordination.
- Close coordination of remediation between several sites is critical
- Pre-remediation between sites requires interface.
- Contractor accountability/liability is critical
- Management of more than one contractor presents unacceptable administration problems such as areas as coordination and movement of work forces and equipment.
- Conditions indicate there will be a need for the contractor to respond quickly to situations without interference from another contractor working in close proximity to the site.

When the Army Corps needs work performed under the TERC, the scope and price is negotiated and then defined in a site-specific delivery order. The delivery orders are either cost plus a fixed fee or cost plus an award fee contract. These contracts transfer more risk to the owner, and therefore the owner requires the contractor to participate in a partnering agreement on all delivery orders.

The following are recognized advantages to this approach[66]:

- Clear identification of the responsible contractor
- More effective control by the contractor over the work they are responsible for completing
- Elimination of the long and difficult transition between the design and the construction. This is especially useful for sites that require relatively little design work.
- Faster resolution of problems encountered on the site
- More effective management and interface between contractors (general contractor and the subcontractors) in scheduling and completing the work

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[66] *Missouri River Division Acquisition Plan.* p. 7.

- Faster and more fluid operations on-site
- Work can begin quicker because the contract is already in place, so the Corps does not have to go through the lengthy procurement process.

Firms awarded a TERC must be able to perform the following tasks through either a joint venture or through managing subcontracts:

Predesign Activities:

Preliminary assessments
Site investigations
Remedial investigations
Feasibility studies
Treatability, testing, and computer modeling
Decision document preparation and processing
Related studies and assessments

Design Activities

Design drawings and plans
Specifications
Design analysis

Remedial Activity

Excavation
Removal and transportation of waste
Demolition
Disposal
Well drilling and installation
Treatment plant construction
Monitoring system installation
Treatment plant operation (short term O&M)
Implement existing, improved, and new technology
Waste containment

The first TERC was awarded in 1993 in the Missouri River Division. In the short history of the TERC, there exists too little data on completed projects to draw any valid conclusions on its effectiveness. Table 5-1 shows the TERC contracts in progress:

Table 5-1. TERCs Awarded
Source: Gary M. Pollis, US Army Corps of Engineers, January 1995

Location	Contractor	Date	Amount (millions)
Omaha District	International Technology Corp.	Sept 30, 1993	$160
Omaha District	Rust International	Oct 22, 1993	$150
Omaha District	Ebasco Services Inc.	Oct 22, 1993	$150
Omaha District	Rust International	Oct 22, 1993	$200
New England Division	Ebasco Services	Dec 10, 1993	$260
Tulsa District	Morrison-Knudsen	Aug 18, 1994	$300
Tulsa District	OHM Remediation Services	Aug 18, 1994	$216
Sacramento District*	-	1995	$180
Alaska District*	-	1995	$240
Baltimore District*	-	1995	$330

* Not awarded as of this report.

5.3. The TERC Implemented: the Norwood PCB Superfund Site[67]

The Norwood PCB Superfund Site is currently under remediation through the application of the TERC. It provides an example of how to get a cleanup moving quickly through some of the methods in the last chapter. The Norwood PCB Superfund Site is located approximately 14 miles southwest of the city of Boston. The 26-acre site consists of industrial and commercial parcels of land and associated parking areas. The site is bordered on the north by Meadow Brook, to the east by Route 1 and the Dean Street access road, and the west by the residential Removal Road. Figure 5-1 and 5-2 show the location and the layout of the site.

[67]Background information was taken from three sources: the *Feasibility Study Final Report,* the *Record of Decision Summary*, and the *Norwood Superfund Fact Sheet* produced by the EPA.

Figure 5-1. Location of the Norwood Superfund Site
Source: Record of Decision, 1989

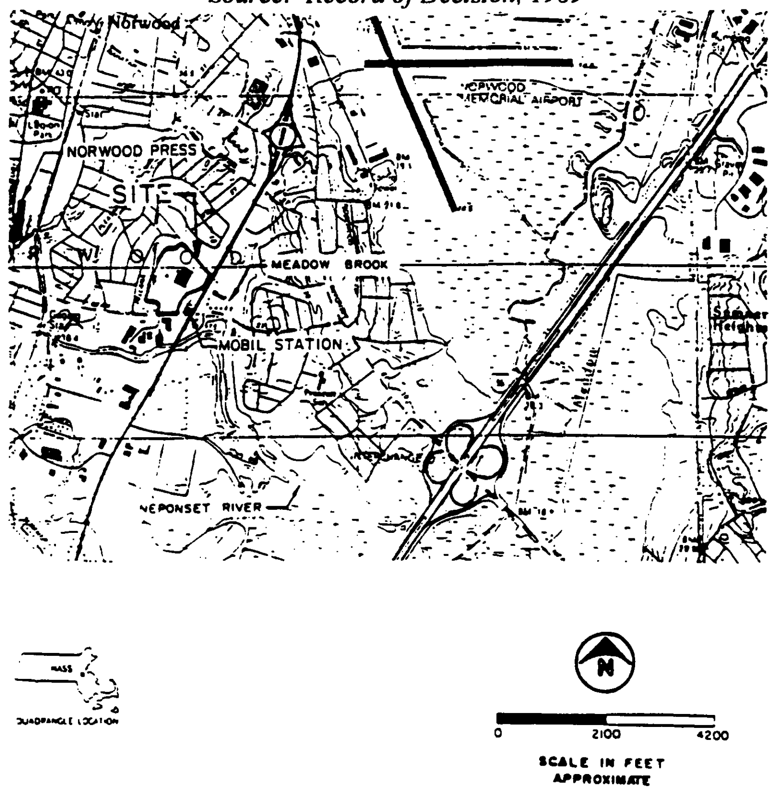
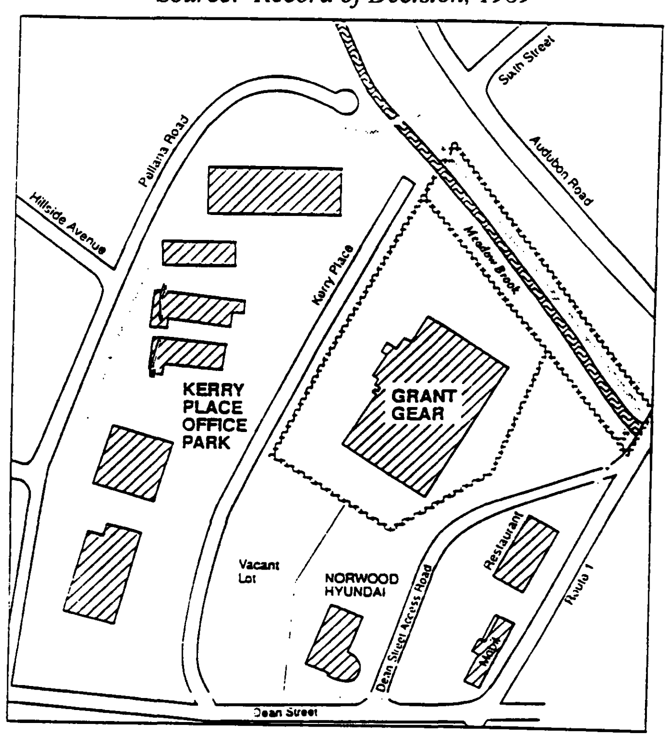


Figure 5-2. Layout of the Norwood Superfund Site
Source: Record of Decision, 1989



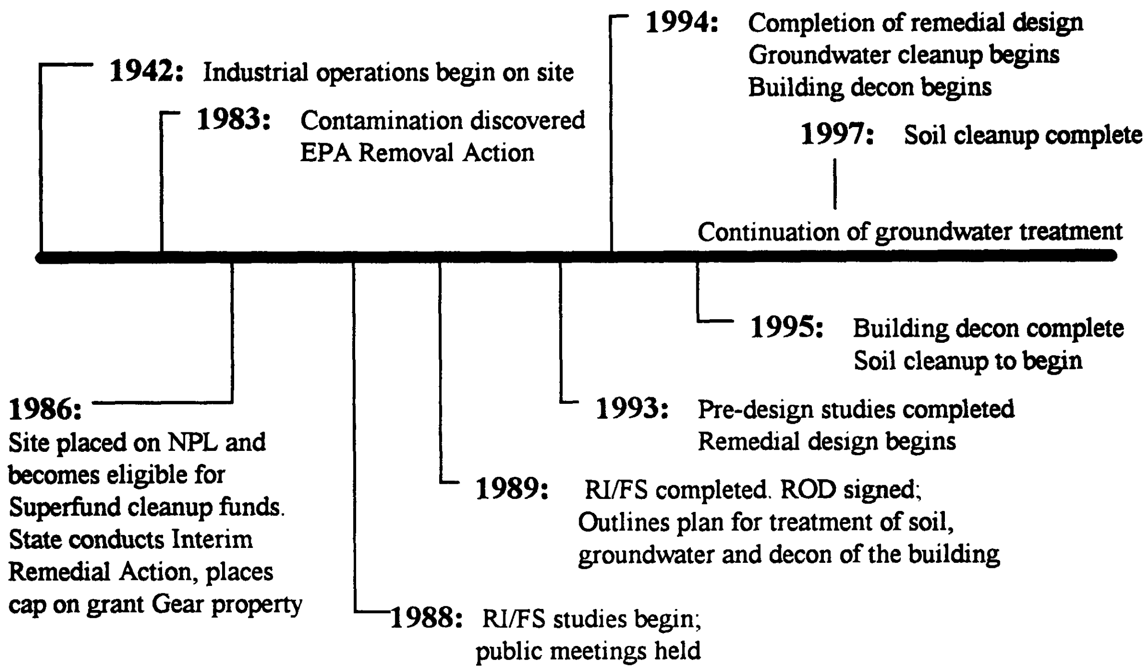
The site is in a heavily populated area. Approximately 250 people worked within the site every day in the Grant Gear Building, the offices located on Kerry Street, and the Norwood Hyundai auto dealership. Two residential areas border the site with approximately 3,040 residents living within a one-half mile radius. Meadow Brook is a shallow stream approximately twelve feet wide and 6 to 12 inches deep near the site. The brook serves as a drain for over 900 acres of developed land and discharges into the Neponset River 1,600 feet downstream of the site.

5.3.1 History of Contamination

Contamination at the site was caused by the disposal practices of the operators of the building since its construction in 1942. The site had numerous different owners and operators, all of which performed some type of manufacturing in the building now called the Grant Gear building. On April 1, 1983, the Massachusetts Department of Environmental Quality Engineering (DEQE, now the Department of Environmental Protection, or DEP) received a phone call from an area resident reporting past industrial waste dumping on the site. The DEQE immediately conducted an investigation to determine the extent of the contamination and found that immediate action was needed. It asked the EPA to use its Superfund to assist in the analysis and the cleanup. The EPA sent its Technical Assistance Team (TAT) and found a number of oil-stained areas and PCB "hot spots" with contamination above the danger level of 50 parts per million. From June 23 to August 5, 1983, the EPA conducted a removal action that removed 518 tons of contaminated soil and transported it out of state.

The EPA and the state of Massachusetts then began the process to determine what to do with the rest of the site. There was still a large amount of contamination in the soil, the groundwater, and the inside of the facility. In 1984, the DEQE limited access to the site by installing a cap over a 1.5 acre portion of the two different locations (see Figure 6-3.) In December 1983, the site was reviewed by the EPA Field Investigation Team (FIT) and evaluated, using the Hazard Ranking System, for possible ranking on the National Priorities List and eligibility for Superfund funding. The FIT took 10 months to determine that it would recommend the site for Superfund money, and the site was eventually added to the NPL on June 10, 1986. There is no satisfactory explanation of why it took two years to move through this system. The EPA had apparently become so engrossed in its own regulations and bureaucracy that it allowed this site to sit for years without any action. Figure 5-3 is a timeline of activities for the site:

Figure 5-3. Activity Timeline for the Norwood Site
Source: US EPA Fact Sheet, 1994



Throughout the site's history, numerous studies and assessments were performed in order to determine the extent of the contamination. The following table is a summary of the investigations performed.
Table 5-2 is a summary of the assessments that were performed by various agencies.

Table 5-2. Summary of Investigations, Norwood Site
Source: Record of Decision, Norwood Site, 1989

Date	Name	Client	Activity	Comments
4/83	DEQE		Surficial soil, stream sediment, and surface water sampling	Composite soil sample containing 11% PCBs. Surface water data unavailable. Data not used in the RI due to uncertain sample location

(Table 5-2 cont)

Date	Name	Client	Activity	Comments
4/83	Norwood Engineering	Reardons	Test pits for percolation tests	Highly permeable soils were encountered. DEQE was present and tested one hole for VOCs using a photo-ionization detector. No VOCs above background were detected
5/83	E.C. Jordan Company	Grant Gear	Surficial soil, drainage system sediment, stream sediment, interior building surfaces, and indoor air sampling	Air and interior surface PCB data used to evaluate PCB levels within the Grant Gear building.
6/83	Roy F. Weston, Inc.	EPA	Surficial soil sampling	Confirmed DEQE results and triggered EPA removal action
6/83	EPA		Air sampling	EPA concluded that airborne PCBs were present in low concentrations outdoors
9/83	Center for Disease Control		Collection of blood samples from local residents	All samples were found to be in the typical population range
9/83	NUS Corporation	EPA	Surficial soil, subsurface soil, sediment, and surface water sampling	NUS concluded that surficial soils within the Grant Gear property contained high levels of PCBs, but that most of the rest of the soils were relatively uncontaminated. Data not used for site assessment due to lack of laboratory analysis of duplicates and uncertainty of sampling locations.
10/83	Weston Geophysical	EPA	Surface magnetometer and ground penetrating radar surveys	Several anamolous areas identified. Those on the Grant Gear property were later investigated by GZA. Data used as reference material in the RI.

(Table 5-2 cont)

Date	Name	Client	Activity	Comments
12/83	WEB Engineering	Reardons	Surficial soil and groundwater sampling	Surficial soil results have not been made available. Groundwater was generally uncontaminated except adjacent to the Grant Gear property. Data not used in the RI due to confusion concerning well locations and details.
4/84	Bionetics Corporation	EPA	Analysis of historical aerial photographs from 1952, 1957, 1960, 1969, 1972, 1978, and 1980	Photographs used as reference material to investigate disposal locations.
12/85	Wehran Engineering	DEQE	Surficial soil and subsurface soil sampling and monitoring well installation	PCBs found as deep as ten feet. Data is acceptable for use in FS. Groundwater not sampled as part of well installation.
12/85	GZA	Cornell-Dubilier	Air, surficial soil, subsurface soil (test pits), sediment, dredge spoil pile, and surface water sampling.	Test pits were excavated at geophysical anomalies. One crushed drum encountered. PCB screening data are acceptable for use in FS. Some laboratory analyses not acceptable due to high detection limits and suspected laboratory contamination. Some sampling locations not well-documented.
6/87-8/87	CDM	EPA	Sediment, groundwater, and drainage system sampling	Groundwater data not used for site characterization because monitoring wells were not purged prior to sampling.
6/87	Certified Engineering and Testing	Grant Gear	Splits of sediment and drainage system samples obtained from CDM.	Samples taken to support application for NPDES permit. Data is acceptable for FS.

(Table 5-2 cont)

Date	Name	Client	Activity	Comments
11/87 -3/88	CDM	EPA	Subsurface soil sampling beneath building, remote televiewer and dye testing at drainage system, and sampling of building drainage systems	Data acceptable for use in FS.

In addition to the previously-noted assessments, the EPA conducted more field investigations from September 1987 to May 1989 in preparation of its Record of Decision to achieve the following objectives:

1. Conduct a comprehensive characterization of the nature and extent of contamination in the various media at the site
2. Perform an evaluation of present and future health risks and environmental impacts resulting from the contamination at the site
3. Collect sufficient data to be used in preparing a Feasibility Study to screen potential remedial technologies and assemble and evaluate potential remedial alternatives for the site.

5.3.2. The Contamination

The following is a summary of the most significant contamination set forth in the Record of Decision:

Soil: Approximately 31,550 cubic yards of PCB-contaminated soil was discovered on the site. The studies indicated that the western and northern portions of the site were the most heavily contaminated, with the highest concentrations were over 26,000 ppm.
Sediments: PCB contamination was detected in the Meadow Brook sediment, a dredge pole sediment, and sediment from the building's drainage system. The sediment contamination was most likely caused by erosion of contaminated soils and by the contamination of the drainage system.
Groundwater: Contamination of the groundwater was discovered during a two-phased investigation by the EPA in 1988 and 1989. The installation of twenty-six groundwater monitoring wells determined that the groundwater was contaminated with PCBs and

Volatile Organic Compounds (VOCs), but the contamination was limited to the boundaries of the site.

Grant Gear Building: Three separate tests were performed on the inside of the building: one in 1983 by E. C. Jordan for the Grant Gear Company, one in 1988 for OSHA, and one in 1989 by the EPA. All studies indicated that the there was PCB contamination spread randomly throughout the building.

The overall contamination levels were determined to be too high a threat to human health, and therefore the site needed to be cleaned.

5.3.3. Analyzing the Alternatives

CERCLA, the National Contingency Plan for the management of hazardous waste sites, and the EPA guidance documents, including the "Guidance on Feasibility Studies Under CERCLA", "Interim Guidance on Superfund Selection of Remedy", the Interim Final "Guidance for Conducting RIs and FSs under CERCLA", and the "Additional Interim Guidance for Records of Decision", set forth the process by which remedial actions are evaluated and selected. These documents provide the following nine factors that the EPA should consider in its evaluation and selection of remedial actions:

1. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)[68]
2. Long-term effectiveness and permanence
3. Reduction of toxicity, mobility, or volume
4. Short-term effectiveness
5. Implementability
6. Community acceptance
7. State acceptance
8. Cost
9. Overall protection of human health and the environment

These factors were applied to a number of alternatives that the EPA developed. These potential remedies were divided into four categories:

1. Alternatives for the decontamination for the inside of the Grant Gear building

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[68]Applicable, relevant, and appropriate requirements, or "ARARs", are used by the EPA in developing cleanup goals at sites.

2. Source Control alternatives which address the soil and sediment contamination at the site
3. Source Control alternatives which address the contamination of the drainage system
4. Management of Migration alternatives which address contaminants that have migrated from the original source of contamination into the groundwater.

The following three alternatives were considered for the decontamination of the inside of the Grant Gear building:

Sandblasting: This option was screened out based on the uncertainty of its effectiveness in reducing contaminant levels on metal and concrete surfaces to the target levels. Also, the sandblasting may have posed a short term risk to workers from increased airborne contamination during the sandblasting operation.

Removal of the Contaminated Equipment: This option was ruled out because it would be costly due to the problems associated with transporting a large mass and volume of contaminated equipment without actually reducing the level of contamination.

Decontamination of the Equipment: This option was selected because it was a permanent solution that was possible to implement.

Because only one alternative passed the initial screening, no detailed analysis of the alternative for remediation was performed.

Alternatives for the Contaminated Soil, the Drainage System and the Groundwater

The EPA established a list of all possible alternatives that could be used for remediation at this site. Tables 5-3, 5-4, and 5-5 on the following four pages summarize these alternatives and the advantages and disadvantages of each.

Table 5-3. Summary of Alternatives for Soil Remediation

Option	Description	Advantages	Disadvantages	Time to Implement	Total Cost
SC-1 Minimal Action	Primarily consists of restricting access to the contaminated areas through construction of a fence and institutionally controlling land use	Easy to implement Inexpensive	Does not address human health and environmental risks due to exposure to contamination Not a permanent solution (i.e. does not reduce the level of contamination) Does not attain state ARARs	<1 year	$1,082,000
SC-2 Capping of Soils	Consolidate outlying contaminated soils into capped piles, replacing the soil with clean fill	Easy to implement Short term protectiveness to human health Inexpensive	Does not reduce the level of contamination Not supported by the community	<1 year	$3,997,000
SC-3 On-Site Solvent Extraction	Construction of a solvent extraction system that uses solvents to flush the contamination from the soil	Permanent solution that removes the contamination from the site	Innovative technology that may not work Pilot study must be performed to determine its effectiveness	2 years	$13,260,000
SC-4 On-Site Dechlorination	Construct a mobile treatment unit that detoxifies the PCBs	Permanently eliminates the contamination	Innovative technology which has yet to actually demonstrate its effectiveness Construction of mobile unit has never been done	2.5 years	$15,633,000

(Table 5-3 cont.)

Option	Description	Advantages	Disadvantages	Time to Implement	Total Cost
SC-5 On Site Incineration	Construction of an on-site incinerator that would eliminate 99.999% of the contamination from the soil	Readily too implement (i.e. proven technology) Permanently eliminates the contamination	Not supported by the community Most expensive option	2 years	$17,119,000

Table 5-4. Summary of Alternatives for Drainage System Remediation

Option	Description	Advantages	Disadvantages	Time to Implement	Total Cost
SC-A No Action	Self-explanatory	Inexpensive	Does reduce level of contamination Requires long-term monitoring Continued discharge into Meadow Brook would recontaminate the brook	0	$57,000
SC-B Flushing/ Cleaning	Purge current system using approved pipe-cleaning techniques; collect sediment and treat sediments on-site	Easy to implement Inexpensive	May not eliminate all contamination	<1 year	$99,000

(Table 5-4 cont)

Option	Description	Advantages	Disadvantages	Time to Implement	Total Cost
SC-C Containment	Initially flushes the current system and then fills it with concrete; construct a new drainage system	Reduces the mobility of the contamination Eliminates existing release to Meadow Brook	Does not eliminate contamination Requires long-term monitoring and reviews	<1 year	$240,000
SC-D Removal of Drainage System	All contaminated piping and manholes removed and transported to an off-site facility; replace the system as necessary	Permanently stops the discharge of hazardous compounds to Meadow Brook	Disrupts the operations of the Grant Gear facility Involves major excavation Most expensive alternative	<1 year	$440,000

Table 5-5. Summary of Alternatives for the Groundwater Remediation

Option	Description	Advantages	Disadvantages	Time to Implement	Total Cost
MM-1 Minimal Action	Prevent groundwater use through the use of deed restrictions; use town meetings to keep the public aware of the hazards	Easy to implement Inexpensive	Does not reduce contamination Requires long-term monitoring Plume could migrate further off the site	<1 year	$967,000
MM-2 Air Stripping	Pumps water to a constructed facility that use air flow to remove the contamination from the water	Permanently removes contamination from the water	Requires long-term management of residuals	10 years	$2,501,000

(Table 5-5 cont.)

Option	Description	Advantages	Disadvantages	Time to Implement	Total Cost
MM-3 Carbon Adsorption	Pump water to a granular activated carbon adsorption (GAC) unit; carbon beds capture the PCBs and then are transported off-site to an incinerator	Permanently reduces the contamination level Easy to implement	Requires long-term monitoring of waste residuals, including sludge and carbon	10 years	$2,326,000
MM-4 Ultraviolet Oxidation	Pump water to a UV oxidation system	Slightly less expensive than the other options Permanently and significantly reduce contamination levels	Innovative technology that would require pilot testing Requires long-term management of waste residuals Limited availability of vendors	10 years	$1,807,000

Source (Tables 5-3, 5-4, 5-5): Record of Decision, Norwood Site, 1989

5.3.4. The Selected Remedy

The numerous studies and years of investigation resulted in the EPA issuing a Record of Decision on September 29, 1989. This ROD declared a "Selected Remedy" that would dictate how the site was to be cleaned up. The selected remedy for the Norwood Site is a combination of Source Control 3 (On-Site Solvent Extraction), Source Control B (Flushing/Cleaning of the Drainage System), and Management of Migration 2 (Air Stripping). The decision to use these methods was based on a comprehensive analysis conducted by the EPA, and it was based on ARARs and regulations dictating the protection of human health. The most glaring weakness of the remedy selection process was that it was not the result of a unified, coordinated effort, but rather it was EPA officials considering the many disjointed studies and trying to decide which methods was the best. Furthermore, the ROD was handed down years before any excavation had begun, which arguably is the only time subsurface conditions can be accurately determined.

The following is a summary of the activities that would have to take place during the complete remediation:

Site Preparation
These activities are often simple for a non-hazardous construction project, but here they involve implementing protective measures against the hazards of the contaminants for the workers and residents in and around the site. These include the construction of a perimeter fence, implementation of a stormwater management system, and the implementation of an air monitoring program. Soil monitoring must also be performed to further define soil contaminant levels in the areas affected by the site preparation work. Following the installation of these measures, the site sill be cleared and leveled in preparation for the upcoming work.

Remediate Contaminated Soil
This activity is composed of the following: predesign work, excavation, grading, solvent extraction, on-site disposal, backfilling, soil covering, and monitoring. The predesign work will include continuous soil sampling in order to confirm the results of previous tests. For the solvent extraction, a facility must be built that will accommodate all of the

activities involved in the process. When the soil has been cleaned to the required level, it will be put back in the ground, covered with ten inches of clean soil, and revegetated.

Treatment of Contaminated Sediments

This activity will include the following: preparation work, temporary diversion of surface waters, excavation and dredging, implementation monitoring, rediversion of surface waters, dewatering, storage, and on-site disposal. The majority of this activity will take place in and around Meadow Brook. The sediments will be treated in the same solvent extraction process used for the soil remediation.

Cleanup Drainage System

This portion of the remediation involves flushing out the existing drainage system. This stage will need to be done in conjunction with the sediment remediation because the sediments that are flushed out will flow into Meadow Brook and need to cleaned. As much of the contamination will be flushed out as possible, and then the system will be tested. Whatever portions are still contaminated will be abandoned and filled with concrete. New pipes will be installed as necessary.

Clean Building Interior

Cleanup of the equipment and the interior of the building will done by double-washing with solvent and subsequently tested.

Groundwater Remediation

The groundwater cleanup will require extensive monitoring and sampling during the design and remediation system. The ROD calls for the installation of a complex barrier and extraction system that will both contain the groundwater and pump it to a constructed facility. Tests will have to be performed to determine the system's effectiveness and additional wells will be installed as necessary. The pump and treat system will continue to operate until target levels are reached which could take up to twenty years.

Long-Term Monitoring and Reviews

The long term monitoring will be designed for the following purposes:

- To document the changes in contaminant concentrations over time

- To determine the degree to which contaminants in the soil and the groundwater are migrating on and off site.
- To evaluate the success of the remedial action
- To help define the extent of the institutional controls necessary

This monitoring is particularly important because the remedial action will not clean the contamination located under the Grant Gear building or the contamination in the soil under the groundwater.

Clearly, the selected remedy is complex. It involves seven separate activities and numerous studies all to take place in a short period of time and on a small site. Furthermore, some of the steps of the design cannot be completed until the remediation actually begins. For example, the effectiveness of the solvent extraction system on this soil will not be determined until the system is installed and an initial test is run. But the EPA still looked to use its traditional procurement in order to carry out its detailed design. It selected Metcalf & Eddy using the procurement methods set forth in the Brooks Act. This firm spent from 1989 to March of 1994 evaluating the investigations that had already taken place and conducting its own studies in developing its design. Finally, Metcalf & Eddy completed the design of the groundwater treatment system in March 1994, and the Norwood Site was ready to move into the remediation stage.

5.3.5. The TERC and the Norwood Site

The Army Corps of Engineers provided technical assistance to the EPA during the design phase of the project. In the fall of 1993 the EPA assigned the administration and the management of the project to the Corps. The Corps was faced with a challenge that it had seen before: a complex and involved remedial action on a Superfund site.

But now the New England Division had the preplaced TERC at its disposal. On December 10, 1993, the New England Division awarded a $260 million TERC to Ebasco Constructors, which is now Foster Wheeler[69]. The head of the New England Division, Colonel Brink Miller, described the TERC as a method "that gives us the option to wrap

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[69]Ebasco Constructors was taken over in 1994 by another company except for its environmental remediation branch. This branch became Enserch until it was bought out by Foster Wheeler after several months

an entire environmental cleanup process into a single contract with a single contractor."[70] This is precisely the method that was needed for the Norwood site.

In December 1993, there was considerable pressure on the Corps to begin actual remediation at Norwood by the end of 1994. It had been over ten years since the contamination had been discovered and four years since the EPA had issued its Record of Decision, so the public had grown weary of the delays and wanted action. The Corps knew that the groundwater design would be complete in the spring of 1994, and even then there would still be design issues that could not be resolved until more tests were performed and the results evaluated, and it needed a method to get work moving at the site quickly. Also, in a memorandum titled "Project Execution Senior Management Board Action on Acquisition Strategy for the Norwood Superfund Project, the chairman of the Project Execution Senior Management Board at the Corps cited the following reasons for the use of the TERC:[71]

- The site is confined, only 26 acres
- There is some overlapping work and coordination necessary during construction of the various segments of the projects
- An operating business is located on the site with over 250 employees
- Multiple contractors on site would increase the potential for confusion and lack of cooperation

The traditional methods used on remediation projects by the EPA and other government agencies would not be adequate for the site. It would take too long to prepare bid documents, bid the work, and award a lump sum bid. This method would probably result in the project not starting until 1995. Furthermore, the lump sum method would not have allowed for the likely changes to the design that would occur once the remediation begin. The changes were expected because some testing could not be done until the actual remediation had begun. Therefore, this method of awarding a lump sum contract would have been difficult for the Corps to administer. After considering these issues, Colonel Miller approved the use of the TERC for the project.

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[70]"Army Engineers Award $260 Million Total Environmental Restoration Contract". News Release, U.S. Army Corps of Engineers, December 10, 1993.
[71]Scully, William C. "Memorandum for Record: HTRW Project Execution Senior Management Board Action on Acquisition Strategy for Norwood Superfund Project." December 30, 1993

The TERC and the Norwood Site

The TERC at the Norwood Site has proven to be successful so far. The project was divided into three phases: the groundwater remediation, the soil and sediment remediation and the drainage control, and the cleaning of the interior of the building. Each phase would be awarded under a TERC "delivery order". The first delivery order was the groundwater remediation. The other two delivery orders would be awarded in future years. In May and June 1994, the Corps and Foster Wheeler met the first challenge in the project in negotiating a fixed fee contract for the first delivery order. Foster Wheeler initially estimated the work at $10.5 million while the Corps had estimated it to be $8.5 million. After negotiations in which the scope of work was further defined and the two sides discussed the issues, the contract price was set at $8 million. The fee was fixed at 7.2% of the cost, so Foster Wheeler lost money be settling for the lower price. But this was made possible because Foster Wheeler has been assured of a certain amount of work under the TERC, so it did not need to fight with the Corps over the cost.

The Partnering Agreement

An important part of the TERC is the mandatory use of partnering. Once the contract was signed, the Corps had an incomplete design and still more testing to perform. At the same time, it wanted to start the remediation as soon as possible. Therefore, it wanted to "fast-track", or start the construction before the design was completed. This called for cooperation and a mutual effort by the owner and the contractor to keep the schedule and the budget on target. According to the project manager for the Corps, Captain Brian Baker, the goal of the partnering agreement was "not to assign blame but, rather, come to a mutual understanding with the contractor of how to best do business henceforth, capturing lessons learned and applying them to future work at the site."[72]

The partnering agreement had two specific issues that it was to address that were critical to the outcome:

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[72]Baker, Brian. "Norwood Partnering." Memorandum distributed to Corps and Foster Wheeler management, February 9, 1995.

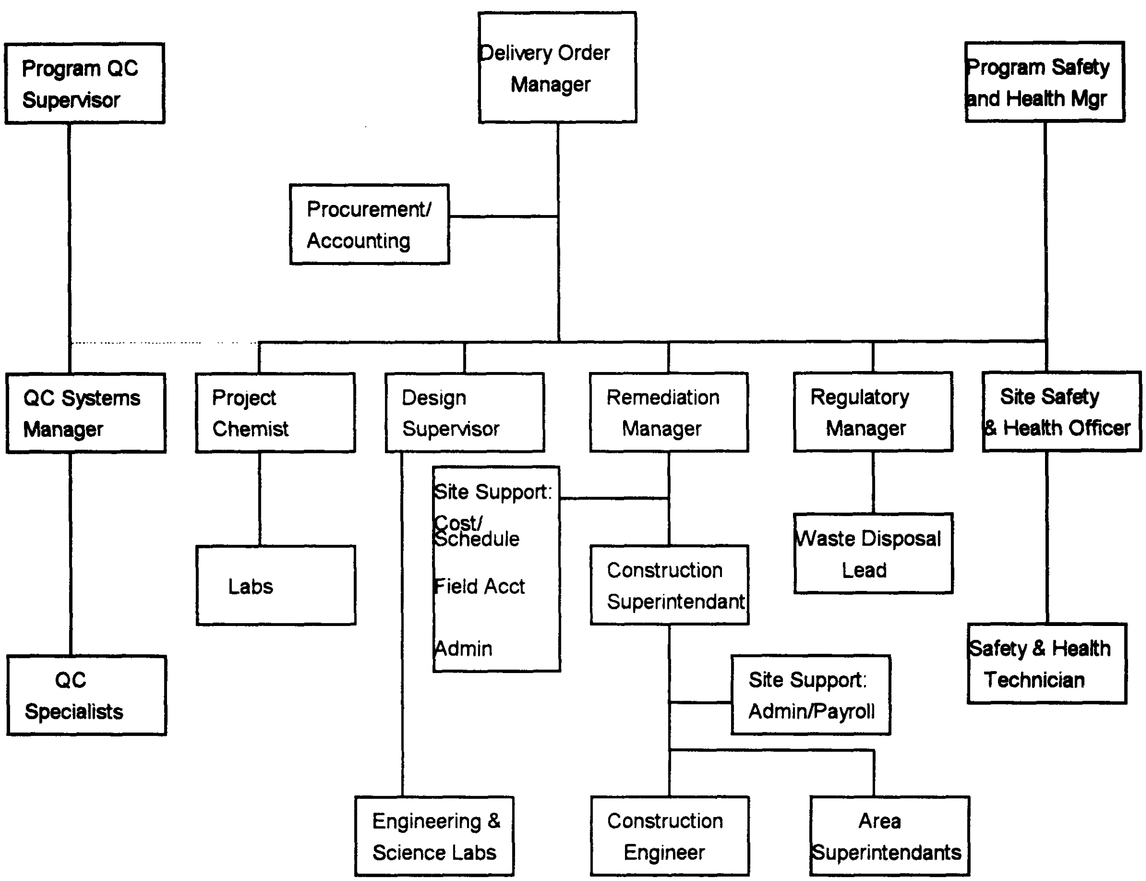
- The Corps decided to use a revised Submittal Register that would limit the number of submittals for government approval and use the submittal register that Foster Wheeler had developed. This would save Foster Wheeler time and reduce the amount of personnel it needed on the job, but it could cause the Corps to lose control of the project and lead to mistakes. Therefore, the partnering was a crucial mechanism that would bring the two sides together and ensure that the contractor was complying with the terms of the contract.
- The Corps and Foster Wheeler agreed to use "on-board" design reviews in which the two sides would meet in order to expedite submittal approvals, minimize rework, and avoid the need for re-submittals. These meetings would require the two sides break from the traditional roles of the owner and the contractor, and instead work together as a team in order to keep the pace of the project moving quickly.

Both of these issues required close cooperation and a mutual trust by the contractor and the owner, so the partnership agreement was an appropriate mechanism to make the cooperation happen.

Project Organization

Figure 5-5 represents the contractor's organizational chart for the groundwater treatment deliivery order.

Figure 5-5. Project Organization Chart for the Norwood Superfund Site
Source: U.S.Army Corps of Engineers, Project Organization



All of the personnel in this chart represent employees of the contractor, Foster Wheeler, or the contractor's partner for the project, Groundwater Technology. The on-site manger is the remdiation manager and his subordinates. He also can draw resources from ony of the other managers upon request to the Delivery Order Manager. Overall, this chart shows a team that is fully capable of meeting the challenges of the site cleanup.

The Army Corps has the following personnel on the site part or full time:

- **Project Manager**: Responsible for overall coordination between the agencies within the Corps and between the Corps and other government agencies.
- **Contracting Officer's Representative**: Responsible for overall Quality Assurance; reviews and monitors contractor's submittal register; prepares payment estimates; reviews contractor's progress
- **Office Engineer**: Responsible for performing QA on contractor's computer-based information systems such as cost control and CAD drawings.
- **Construction Representative:** Responsible for overseeing inspections and tests (observes at least 10% of all tests performed); advises the project manager; performs other duties as assigned

The First Year of Remediation

The first year since the signing of the contract has provided several examples of the effectiveness of the TERC and cooperative relationship that exists on the project:

Remediating the Interior of the Building

This phase of the project is one that shows clearly the shortfalls of the EPA's methods of bringing a project to remediation. The equipment inside the building was contaminated, and the EPA eventually selected a remedy of using a solvent to wipe the remediation from the equipment and the walls of the building. This was a simple remedy requiring virtually no design, and it was expected to take only six to eight weeks to complete. It still took over ten years and the use of the TERC to finally get the building cleaned.

In the TERC agreement with Foster Wheeler, the Corps had planned to execute this phase of the work after the completion of the soil remediation. But because of concern for the safety of the workers in the building, the Corps wanted to clean the building in the winter of 1994-1995. With the TERC, the Corps signed a contract with Foster Wheeler to perform the work and within two months it was complete. The procurement process was simple, and the Corps and the contractor had already developed a good working relationship, so the remediaiton took place quickly. Perhaps had the TERC been in place in 1983, this action could have taken place then, but since the EPA applied its lengthy process to the action, it took over eleven years.

Maintaining Cost and Schedule

Six months into the groundwater treatment, Captain Baker noticed that Foster Wheeler had slipped almost two months behind schedule. He felt that they were not properly updating their schedule, they had a slow procurement process for materials, and they had an ineffective management organization on the site. He sent a letter to Foster Wheeler describing these problems, and Foster Wheeler responded promptly. They reviewed their policies and made changes to their procurement system, their management organization, and their scheduling techniques. All of these changes put the project back on schedule. This type of interaction is not possible when the contractor and the owner have not established a cooperative relationship.

Remediating Soil During the Groundwater Treatment

During the groundwater remediation, contaminated soil that needed to be excavated and stockpiled immediately was discovered outside the boundaries of the site. The soil remediation was not set to begin for at least a year, but this soil needed to be removed sooner than that. In the past, procuring a contractor to perform such work could have taken years. Also, it could have been difficult to obtain the funding required to issue such a large change order to the existing contract. With the TERC, the process worked extremely fast. After discovery of the contamination, the Corps asked Foster Wheeler to assess the areas and develop an estimate for how much it would cost to stockpile the soil. Foster Wheeler developed an estimate, and after a meeting in which the two sides debated the right cost, Captain Baker authorized $97,000 for the change. Foster Wheeler agreed, and within two months the soil was appropriately stockpiled. This quick action certainly would not have been possible had the contractor and the owner maintained an excellent relationship and the TERC was already in place.

Selecting a Vendor for the Soil Remediation

An advantage of the TERC is that the remediation contractor can be included in the selection of a vendor for the innovative technology. The ROD selected solvent extraction for the soil remediation, so the Corps has no choice as to what the method of remediation will be. In the past, the Corps would select a vendor of the technology, and the contractor selected later would be forced to use that vendor. With the TERC, the contractor will be the one to find the appropriate equipment for the remediation. Most likely Foster Wheeler will find the best equipment possible because it will be responsible for its performance. The Corps is paying Foster Wheeler $500,000 to find the vendor, but it hopes that the investment will pay off during the eventual remediation.

The Future of this Project

Opponents of the TERC claim that it spends too much money on one contractor, and it takes the incentive away from the contractor to keep costs down. For example, on many days at the Norwood site, there are as many as twelve management personnel working for the contractor supervising as few as twelve workers. One could look at the contractor's organizational chart and think that are too many people assigned to the project. This could lead to the finding that the contractor is spending too much money on overhead and other costs. It will be difficult to determine if this is the most efficient way to manage a remediation site, but it appears that the TERC has been a success thus far.

5.4. Summary

This chapter showed an innovative method to accelerate the pace of hazardous waste cleanup projects. The TERC has already shown early success, and it is expected that this contracting method will become more widely used into the next century. The Norwood Superfund Site has shown the effectiveness of the TERC in getting the project to remediation quickly. The next chapter will look at a company, OHM, that has experienced tremendous success in remediation and is participating in remediation with the TERC.

CHAPTER 6

OHM REMEDIATION SERVICES, INC.

6.0. Introduction

The previous chapters have identified and demonstrated some significant issues that have faced remediaiton contractors in the past fifteen years. This chapter will focus on one contractor: OHM Remediation Services. This is company that has been through all of the regulatory changes throughout the years to become perhaps the biggest remediation contractor in the United States. "The unusual firm, nestled in the farming heartland of Findlay, Ohio, is infused with a pioneering spirit and a get-the-job-done mentality that has made it a leader in on-site waste cleanup."[73] First this chapter will describe the history of OHM and how it reacted to the changing markets throughout the last twenty-five years. Then, it will examine its current strategy of pursuing work in its core competency of on-site remediation, and finally, it will look at OHM's approach to project management.

6.1. History of the Company

OHM was founded in 1969 in Findlay, Ohio by two brothers, James and Joseph Kirk. Both Kirks began their careers in construction in their father's water and wastewater treatment plant building firm while they were still in college. In 1969, they decided to start an emergency waste cleanup firm because they thought that it was a new, emerging industry and because there was little construction in Ohio in the winter.

OHM's cleanup business soon found itself performing a number of local cleanup jobs. Then, as natural and manmade disasters mounted, a large number of clients began turning to OHM for their expertise. They certainly benefited from a lack of competitors as they found few other firms competing with their hazardous waste business. In addition to emergency response, they also began to gain valuable experience in remediation and construction.

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[73]Rubin, Debra K. "Ohio Cleanup Firm is Ohio's Cash Crop." *ENR*, July 4, 1994, p. 22.

OHM experienced steady growth throughout the 1970's with its core business being emergency response and cleanup. During the 1980's, OHM struggled to find a niche in the market as the regulatory agencies kept firms guessing as to what the focus would be on the environment. At this time, OHM went public and pursued a strategy of becoming a full-service environmental firm. OHM acquired an asbestos abatement firm, a mobile solvent recycling technology firm, a hazardous waste treatment facility, and commercial testing laboratories.[74] It also invested $5 million in a joint venture with Conrail to develop a nationwide network of solid waste disposal sites. It also created three regional centers in Trenton, NJ, Atlanta, and Walnut Creek, Calif.

By the early 1990's, the environmental market changes caused many of these ventures to struggle financially. As a result, OHM sold its testing laboratories, its hazardous waste treatment plant, and a large share of its asbestos abatement firm. In 1990, it decided to commit to focus entirely on what it felt was its core competency: on-site remediaiton. OHM's 1993 annual report describes how it arrived at this core competency:

> "Three years ago [1990], we reviewed each of our business and determined that on-site remediation was not only the business in which we excelled but also is the area that offered the greatest potential for long-term growth. Accordingly, we have sold or reduced our investment in other areas and concentrated all of our resources on strengthening our on-site remediation capabilities."[75]

Many investors did not agree with this decision to expand the remediation business. "The decision didn't go over too well with Wall Street, but we had a longer vision," proclaimed Jim Kirk.[76]

The following figures show the change in focus on the late 1980's and the early 1990's.

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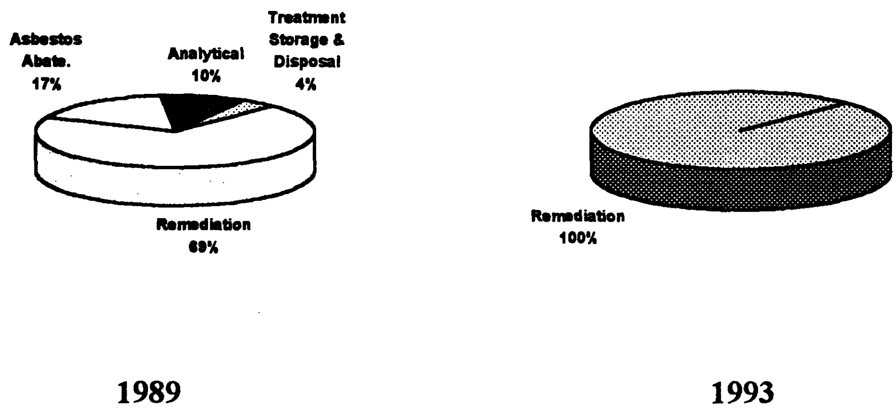
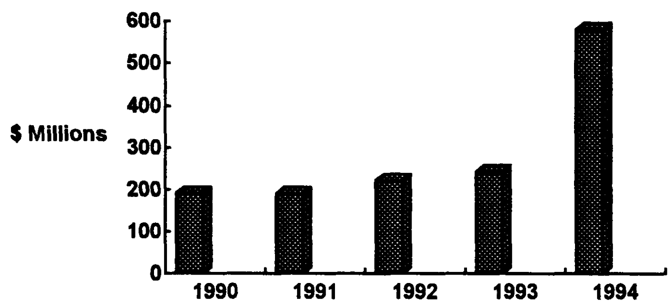
[74] *Ibid.*
[75] 1993 annual Report, OHM Corporation, p.10.
[76] *Ibid.*

Figure 6-1. Focus on On-Site Remediation
Source: OHM's Annual Report, 1993



Obviously, these figures show that OHM has dedicated its entire environmental effort to remediation work. Since this decision to focus on remediation, OHM has achieved enormous success. The following figure shows the revenue growth since 1990:

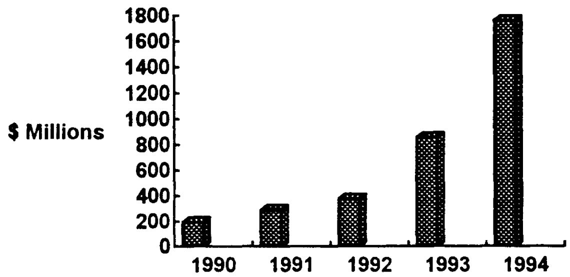
Figure 6-2. OHM's Revenue[77]
Source: OHM's Annual Report, 1994



In addition to focusing on remediation, OHM has sought to build a large contract backlog. (This backlog is defined as work that clients have committed to paying for in the future.) Its remediation services include both planned and emergency work, but the company places its emphasis on planned work because of its more predictable resource requirements, and because of its larger potential market.[78] Figure 5-4 shows OHM's contract backlog over the last five years:

[77]OHM Corporation 1994 Annual Report, p.1.
[78]OHM Corporation 1993 10-K Report, p. 2.

Figure 6-3. Contract Backlog
Source: OHM's Annual Report, 1994



OHM's strategic plan in order to achieve this growth was to focus exclusively on on-site remediation. In order to do this, it had the following three goals for 1994:

- **Develop and maintain a strong national presence**: It achieved this through "geographic expansion and investments in regional infrastructure." Particularly, it sought to strengthen its presence in the southern and western United States. This expansion was obviously successful as it led to a number of contract awards throughout 1994, most notably a $216 million contract with the Army Corps of Engineers.
- **Establish a diversified client base**: OHM does not want to be reliant on a single industry or agency for their work. This also was largely successful as it increased its government work by 84% in 1994. The following figures show how the clients are broken down:

Figure 6-4. Client Mix

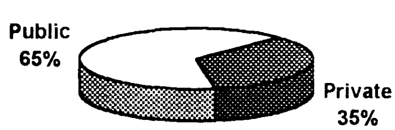


Figure 6-5. Government Sector

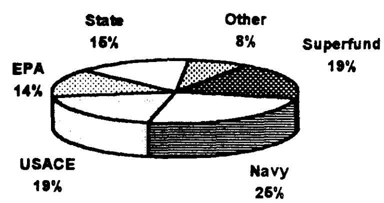
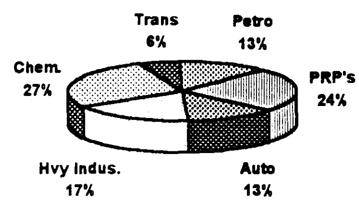


Figure 6-6. Private Sector



Source (Figures 6-4, 6-5, 6-6): OHM Annual Report, 1994

- **Capture long -term projects and contracts**: Having a large contract backlog enables a company to manage its resources due to a more predictable income. OHM's investment on obtaining this type of backlog has enabled it to spend more on its research to develop new technologies.

6.2. OHM's Competitive Advantages

- **Experience**: OHM has completed over 17,000 projects throughout the United States in the last 25 years. Of those projects, OHM has successfully completed over 3,000 emergency response actions. From these projects, it has attempted to capture this experience and learn from it as it developed its technologies. OHM's years of experience in applying innovative technologies on-site enable it to improve efficiencies and reduce the cost of cleanups.[79]

- **Equipment:** OHM owns over $100 million in equipment. It has even been criticized for having too much equipment parked in Findlay. However, this equipment allows them to always have the resources available for a large number of projects, and it allows them to perform much of the remediation work themselves without contracting it out.

- **Technical Expertise**: OHM has recognized the importance of developing technologies in order to meet the complex demands of today's environmental cleanups. "Having diversity in technology - and our engineering expertise - allow us to take advantage of industry trends and unique treatment applications that give us

[79]OHM's 1992 Annual Report, p. 8.

competitive and technological advantages," said George Hay, OHM's Director of Corporate Engineering.[80]

In order to constantly improve its technological capability, OHM has made the following advancements:

1973: Built its own fabrication facility

1978: Built a laboratory dedicated to developing commercial applications of biological treatment of hazardous wastes

1984: Patented the Fluid Injection with a Vacuum Extraction ("FIVE"), a method of decontaminating soil and groundwater by flushing a fluid through the contamination and extracting it through a vacuum

1986: Formed the Technology Assessment and Commercialization (TAC) group

1993: Built a treatability laboratory to support testing and enhancement of a broad range of technology applications

The formation of the TAC has been an important development for OHM. This group studies emerging technologies in order to determine its applicability to actual remediation sites. What is important about the group is that it is entirely focused on how to bring the technology from the laboratory to the field. For example, OHM has become a leader in the field of bioremediation. It started investigating the usefulness of the technology in 1978, and since then has completed over 60 projects using bioremediation. What separates OHM from other firms developing this technology is that it is entirely focused on how to bring this technology to a practical application. And more recently, its large backlog will give OHM the opportunity to test its technology.

6.3. Project Management

OHM believes that professional project management and cost accounting systems are key factors in ensuring that projects are accurately and successfully completed on time and within prescribed cost estimates.[81] Upon notification of a project, OHM will form a project team that will carry out all phases of the remediation. The team works closely with the client to inform, advise, and include the client in all major decisions on

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[80] *Ibid.*

[81] OHM's 10K, 1993, p.2.

the site. The overall project manager will assemble a team that will manage the technical issues, the operations, the administration, and other support functions in order to meet quality, cost, and schedule objectives. In addition, the team will provide the following services: compliance with all health and safety regulations, regulatory compliance, financial tracking, compliance with quality standards, and a single, reliable point of contact.

An interview with Mr. Jay Gooch, Senior Project Manager for the Northeast operations for OHM, provided insight into how OHM approaches a project. There are two senior project managers who oversee twenty project managers. Upon notification of a Request for Proposals or the Notification to Bid, the senior project managers will assign the most qualified project manager to the prepare the bid or the proposal. Once OHM is awarded the job, the senior project managers will assemble the most qualified team to carry out the remediation. If the project requires a particular expertise, then a person will be assigned to that job from within the company. The team will then use all the resources available in the company in order to develop and implement the most time and cost efficient remediation.

During the preconstruction phase, a strong asset for OHM's project management is its "treatability" capability. Treatability is the ability to determine whether or not a solution will work on a site. The previous section described the facilities that OHM has at its disposal to develop the best technology for the remediation. In addition to this technology, OHM has made an addition to its on-site treatability lab that allow it to perform bench-scale tests. Paul Lear, OHM's treatability manager, describes this addition: "A few years ago, treatability was a nice thing to do. Today it allows us to make mistakes on the bench scale and correct them. We can duplicate every technology OHM takes to the field."[82] This capability helps the project manager determine what the best solution will be, and it also convinces a client and even the public that a solution will work. Most importantly, OHM's focus on results on-site have created strong links between this treatability lab and the project managers.

Another advantage to the treatability lab is that it can be used to show clients, government officials, and the public the effectiveness of the treatment. Dennis Galligan,

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[82]Rubin, Debra K. "Ohio's Ceanup Firm...", p. 24.

vice president of commercial sales, says, "We can bring clients in here (the treatability lab) and show them there's a good chance we will succeed."[83]

During the construction/remediation phase, OHM has invested in research to develop software that is unique to remediation. Mr.Gooch explains the following characteristics of projects that are forcing the investment:

- Many projects are relatively simple with few tasks. As a result, it is not worth the investment to spend time using programs such as Primavera. It takes too long to train personnel to use it, and the simplicity of the projects makes it not worth the time.
- Many projects appear the same at the end as in the beginning.
- There are not many experienced project managers as there are in construction.

OHM sees a need for software that is takes into account these aspects of a project. Therefore, it is currently developing software that is not as complex as Primavera and easy to use so that managers in the field can update it easily. This software is proprietary, but the important point here is that OHM has noticed that remediation projects are different from non-hazardous construction projects, and therefore require different project management methods.

6.4. The Tulsa TERC

OHM was awarded a TERC on August 18, 1994 in the Tulsa District of the Army Corps of Engineers for $216,000,000 for a period of four years with two three-year options (the terms of the options will negotiated as necessary). This contract has already shown OHM's ability to move projects quickly from the investigation to the remediation stage.

The Tulsa District of the Corps of Engineers has administered numerous remediation projects in the last fifteen years. Also, they watched Region 6 of the EPA administer large Superfund projects such as the Geneva site in Texas. Like many of the districts in the Corps, it had become frustrated with the slow progress of remediation

[83] *Ibid.*

projects. It also was facing base closures on a number of military facilities throughout its district. So it was excited to see the movement toward a "cradle-to-grave" remediation contract. OHM's dedication to focus on on-site remediation services has appeared to be a perfect match for Tulsa. The Tulsa District developed the following objectives for this TERC:

- Cost control and schedule attainment
- Streamlined and cost-effective remediations
- Application of all remediaiton technologies
- Multiple Delivery Order performance simultaneously
- Interaction with clients and contractor to develop plans within regulations
- Efficient and expeditious execution of plans
- Continuity of personnel throughout all phases of a project

In order to meet these objectives, OHM has assembled a team of almost 4,500 personnel, 56% remedial action personnel and 44% dedicated to investigation and design. It has agreed to perform the following services at designated facilities:

Predesign:	Site definitions, studies, preliminary investigations, site investigations, remedial investigations, and risk assessments
Design:	Feasibility Studies and analysis, decision documents, plans and specifications, as-built drawings, engineering
Remedial Action:	Interim actions, remediation, construction, containment, removal, transport and disposal
Operations and Maintenance:	Treatment, short-term operations, closure

In the first five months of the contract, the Corps has already awarded six delivery orders on projects that could have taken years to complete. The project manager for the Corps, Ramona Wagner has been pleased with the results. She notes that in a short period of time, OHM has gotten involved with projects and moved them toward remediation. The following is a summary of the sites that OHM has already taken strides toward cleaning:[84]

[84]Hazardous Toxic and Radioactive Waste Resident Office, Delivery Order Award Summary, Jan 1995.

Walker Air Force Base

Activity/Project Title	Amount	Date
PRP Tech Support	$1,197,462	Sept 20, 1994
Site Investigations	$1,085,111	Dec 23, 1994

(Additional work is expected at Walker in the remainder of the year.)

Longhorn Army Ammunition Point

Activity/Project Title	Amount	Date
Administrative Records	$100,991	Jan 24, 1995
Construction of landfill cap	$8,000,000	May 15, 1995

Reese Air Force Base

Activity/Project Title	Amount	Date
Design of interim corrective action (groundwater treatment facilities)	$125,000	Feb 10, 1995
Construction of interim corrective action	$1,600,000	June 30, 1995 (est)

Vance Air Force Base

Activity/Project Title	Amount	Date
Removal of paint stripping tank	$835,000	Feb 10, 1995
Physical containment	$1,800,000	Mar 31, 1995
Groundwater Treatment	$1,100,000	Mar 31, 1995

Corpus Christi Army Depot

Activity/Project Title	Amount	Date
Work plans for construction of fuel farm tanks	$72,000	Nov 15, 1994
Tank system design	$170,000	Feb 28, 1995
Tank system construction/ Removal of old tanks	$1,600,000	May 1, 1995

Fort Sill, Oklahoma

Activity/Project Title	Amount	Date
Powder burn area remediation	$1,200,000	Mar 31, 1995
Oil Storage area remediation	$5,000,000	Mar 31, 1995

These sites show that with the TERC , OHM can move quickly toward implementing a solution to a site. The Corpus Christi site is an excellent example. In only six months, OHM has taken the project from developing work plans to beginning the actual construction and remediation.

OHM's Project Management for the TERC

OHM's capabilities are a perfect match for the provisions set forth in the TERC. John Ollsen, the Senior Project Manager for OHM for the TERC, describes that the between OHM and the TERC, the cleanups can move forward much faster than traditional methods. OHM's ability to focus on remediaiton as opposed to characterization will allow them to move quickly and efficiently on the installations in Tulsa's district.

The following is the Standard Operating Procedure for the execution of all Delivery Orders issued and all projects performed under the TERC Program:[85]

1. OHM's project execution strategy is to have our representatives work at all times to develop, foster, and implement the spirit of Partnering with the Corps of Engineers; their clients; internal OHM organizations; team and other subcontractors; and other parties directly involved with the delivery orders/projects of this contract to provide effective environmental and political solutions in an expeditious and cost effective manner.
2. Project execution will be accomplished through the use of a consistent project management team for the life of the project. This team will be initially selected by the Program Manager to review and comment on the preliminary Statement of Work

[85]"Standard Operating Procedures." OHM Remediation Services Corp., Total Environmental Restoration Contract, November 18, 1994, p. 1.

(SOW) initiated by the Corps of Engineers. The project team will consist of a project manager and the appropriate technical resources to review and comment on the SOW.

3. OHM's approach to the review will be to identify the appropriate presumptive remedies and the performance of the risk assessment to determine risks to the public and the environment. Figure 6-7 represents OHM's decision path to developing recommendations for actions on a site.
4. Upon issuance of a delivery order, which incorporates the review comments by the Corps, OHM's Project Manager will review with the program management office staff to confirm that all necessary disciplines required to complete the project will be available and assigned as required. Project team members should include a cost/schedule engineer; QA/QC; health and safety; accounting/finance; technical resources; operations; and general administration. Each project will have an assigned representative from each of the areas and based on the size of the project will determine the full or part time use of the personnel.
5. The Project Manager is responsible for submitting the proposal to the Corps and participating in the negotiations of the delivery order. Often times, the program office will be assigned project specific responsibilities and assume a project team role.
6. The project manager is the single point of contact for a specific delivery order and is responsible for cost, schedule, and performance of all activities on the project to be performed in accordance with the SOW, approved work plans, and all applicable laws and regulations.
7. The project team, as appropriate, will remain consistent throughout the life of the project. Staffing changes will be made only with the approval of the Project Manager and the concurrence of the Program Manager. All project team key staff changes will also receive the approval of the Corps' HTRW Resident office.

The SOP clearly shows OHM's commitment to an effective way of doing business with the Corps in the execution of its projects. Figure 6-7 is the approach that OHM will take for all remediation projects that it receives under the TERC. This approach will allow OHM to respond to requests and make decisions quickly.

Figure 6-7. Project Approach for the Tulsa TERC
Source: OHM Standard Operating Procedures, Nov 18, 1994

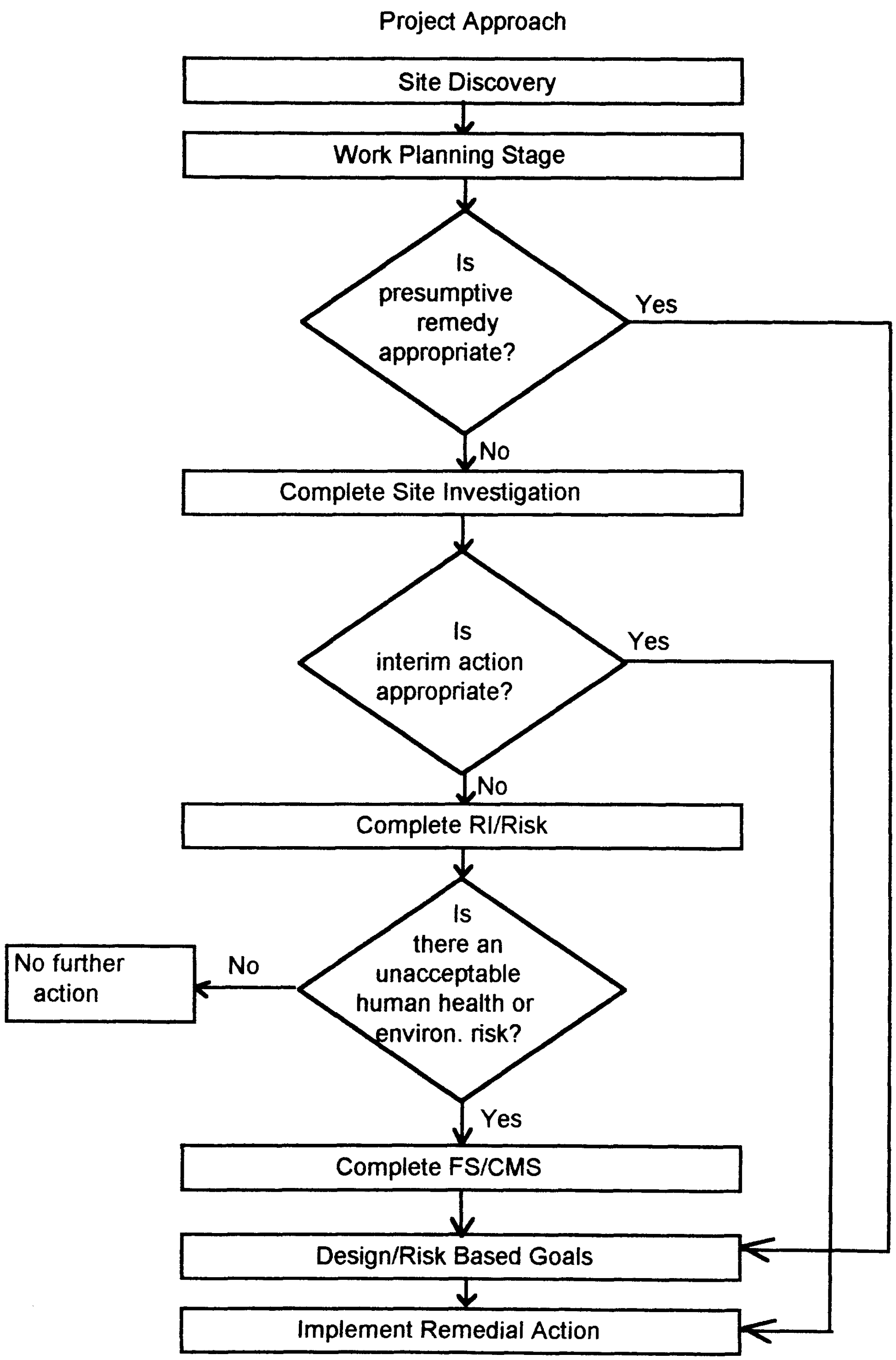
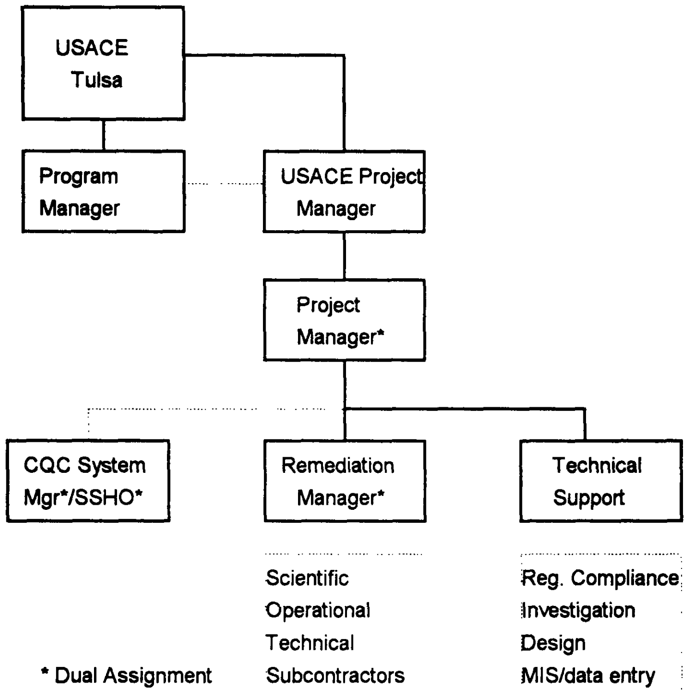


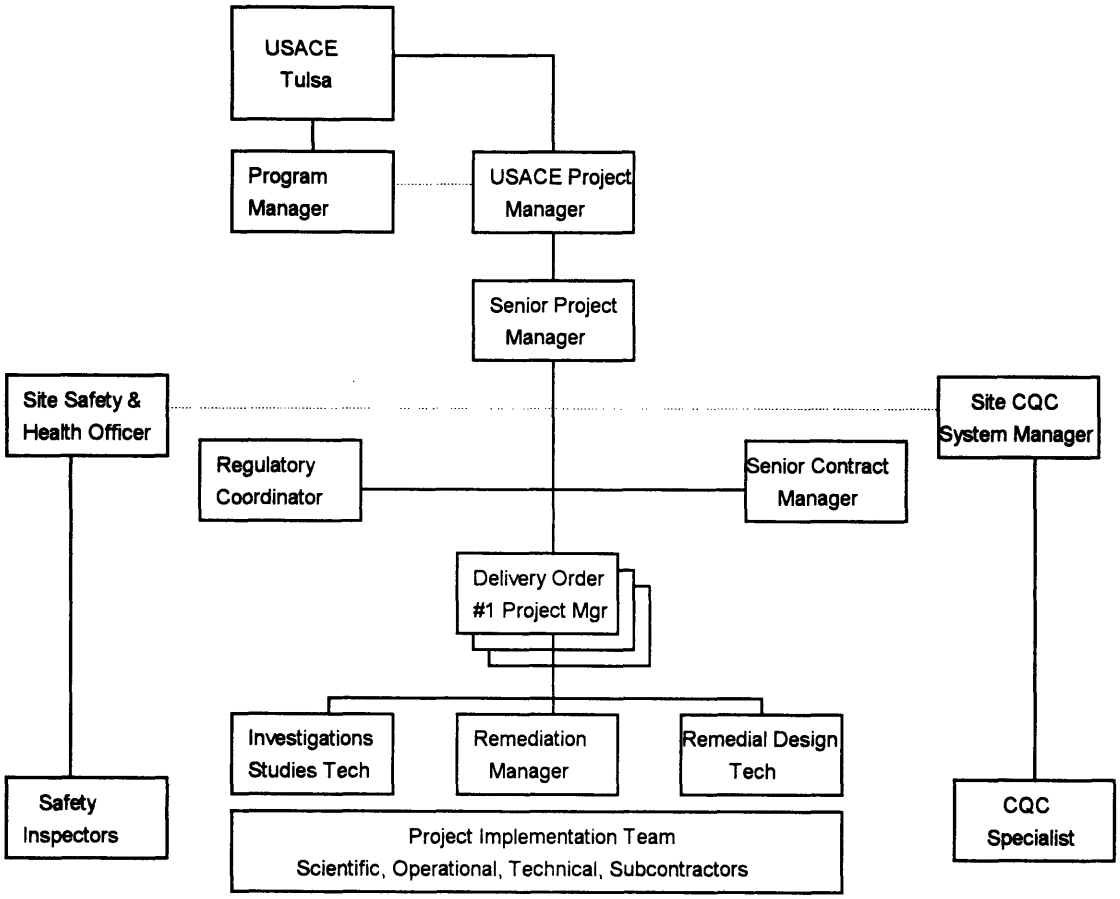
Figure 6-8. Typical Project Organization for a Single Delivery Order Site

Source: OHM Standard Operating Procedures, November 18, 1994



This chart, although not complex, shows the resources that OHM is able to bring to any site. For a large site with multiple delivery orders, OHM has a more detailed staff. Figure 6-9 shows the project organization on such a large project.

Figure 6-9. Project Organization for a Large Site with Multiple Delivery Orders
Source: OHM Standard Operating Procedures, November 18, 1994



This chart is an example of project organization on a large site. Although the TERC has been in place for less than a year, OHM's procedures and capabilities have already shown that they can produce results with the Corps of Engineers and the TERC.

6.5 Summary

Throughout the 1980's, consulting and engineering firms dominated the hazardous waste remediation market. As projects now move forward into remediation and clients and the public grow weary of the slowness of the remediation process, companies that can bring results in the field should dominate the remediation industry. OH Remediation Services has become the nation's largest on-site remediation contractor by focusing on the end of the project rather than on the assessment and design.

CHAPTER 7

RECOMMENDATIONS/CONCLUSIONS

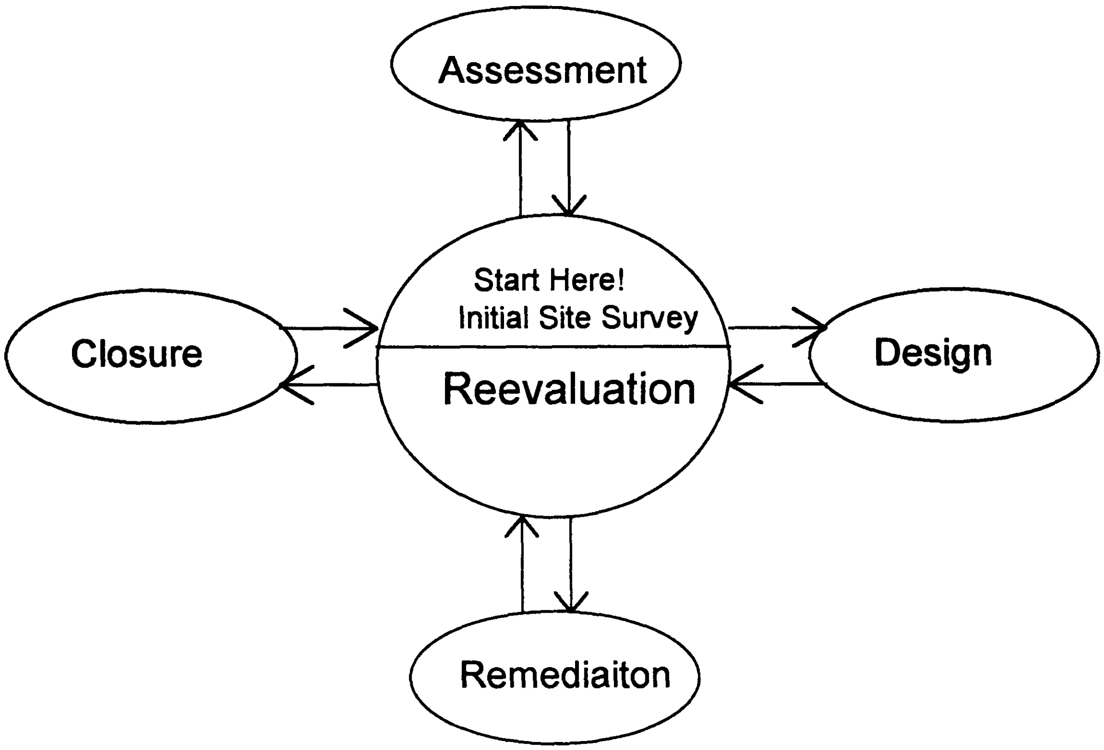
7.0. Overview

This thesis has shown that hazardous waste remediation projects present challenges to regulatory agencies, remediation firms, and project managers that had not been anticipated and were not dealt with appropriately. In the last five years, though, the players in the remediation industry have begun to find methods to manage projects that should produce more efficiently managed projects. As environmental managers gain experience in remediating contaminated sites, there should be less of a need to for site assessment and characterization and more of a need for the effective implementation of the technology. Throughout the 1980's, the issue on a contaminated site was *how* to clean it up. The client would hire engineers and consultants to analyze a site and discover a method that would work be effective for a given contaminant. But now that data is available for many contaminants, the challenge is not how to clean up a site but rather how quickly and how cheaply. This shift completely changes the way a project should be managed from a sequential approach to an interactive one. This chapter describes some techniques that could improve the way a company manages a project and the way it interacts in the remediation market.

7.1 Different Approaches to Remediation

The most important element in effective management of a remediation is the constant focus a contractor should maintain on the final product: a remediated site. All of the processes used previously to get from the discovery of contamination to actual cleanup follow a sequential list of steps that must be followed. As regulators such as the EPA become more flexible in the processes they use, contractors should get away from the sequential process and move toward a methodology that allows for interaction between all of the stages in a project. Figure 7-1 is a diagram that outlines this interactive methodology among the stages.

Figure 7-1. A Methodology to Remediation



The purpose of this diagram is to show that instead of looking at a project as a set of distinct phases, a contractor can view a project as a constant effort to remediate. Every project should begin with an initial site survey consisting of the following:

- An assessment of the type and quantity of the contamination and the scope of work
- A scan of the regulatory requirements that are applicable to the site
- Development of initial plan, cost estimate, and schedule.

The process that OHM uses to mange a project on its TERC is an excellent example of an approach that leads to a speedy remediation. The next two sections give some ideas for more effective methods for managing projects.

7.1.1. Pre-Construction

The result of this initial survey is that the contractor and the owner know what the scope of work will be and can begin developing a plan of action. A project does not need to become entrenched in years of assessments, but instead it can move directly into remediation as necessary. Also, projects should be broken into different phases in order to isolate areas of contamination that can be remediated in different ways. For example, at the Norwood site, a contractor and the government agency could have cleaned the inside of the building years ago rather than wait for a detailed design of the entire facility.

Environmental scientists and engineers are vigorously working to improve the methods used to characterize the site. This effort has arisen because Superfund and previous remediation projects showed that not being able to properly characterize a site can lead to cost overruns and time delays. Now, efforts are made to use techniques such as three-dimensional modeling to develop an accurate picture of the underground conditions. These technologies will become valuable in determining the extent of the contamination at large sites.

Contractors, though, should consider not focusing on perfectly characterizing the site. Instead, a contractor should accept that underground conditions possibly may never be completely determined prior to excavation or remediation. Therefore, a way to more quickly clean up a site is to determine the type of contaminant and approximate quantities, but not conduct an in-depth assessment of the site. Then, begin the project using improved field-analysis kits, and test and evaluate the conditions as the remediation takes place. There will certainly be changes, but the contractor and the owner can be prepared for these using a strong partnering arrangement. It could save money on the total project cost even though there are a number of changes, but the changes do not represent wasted money, but rather money that was not expected to be spent. Thus the contractor should consider that changes are not necessarily bad for a project, but rather characteristic of remediation.

This type of approach requires well-trained managers who are able to make decisions in the field concerning changing the original plan. Also, it requires a flexible contracting method that incorporates change management clauses and the use of partnering techniques. It may be extremely difficult to convince a client to begin a project without knowing what the final cost will be, but this may be the least expensive way to clean up a site.

Another development in remediation that will allow for a faster assessment is that data should become available that tells what the best method is to remediate certain chemicals. Many innovative technologies currently are being studied, so in a few years these methods could be reliable methods for remediation. This should reduce the amount of time it takes to assess a site for the best remedy.

7.1.2. Remediation

A contractor should develop a methodology to use as a guide to get through a project. The following figure is a diagram used by a project manager at Camp Dresser & McKee.

Figure 7-2. Project Management Guide
Source: Christine Fairneny, CDM, 1995.

Plan Development +	Execution (Monitoring During Execution) +	Change Control (Midcourse Corrections) =	Quality Deliverables Profit
Scopes of Work Objectives Deliverables	Earned Value System	Staff/Additions/ Deletions	Good Client Audits
Work Breakdown Structure	Schedule Updates	Constantly update schedule	Repeat Work
Staffing	Relationships with the client	Change Orders	No lawsuits
Budget	Health & Safety	Modify Work Plan	Maintain Profitability
Work Plans Client Deliverables	QA/QC	Estimates to Complete	
QA/QC Plans			
H&S Plan			
Assessment of Risk			

A guide such as the one above along with developing a strong partnering arrangement will be essential to remediation projects in the future.

7.2. Topics for Future Research

The following are three topics for future research related to this thesis:

Evaluation of the Success of the TERC and Other Pre-placed Contracts

A trend in the 1990's is to use pre-placed contracts such as the TERCs in order to make an efficient remediation possible. The Army has committed over a billion dollars to the TERC, and the rest of the DOD has also begun using there own forms of the pre-placed contract. The early success of these contracts could lead to an increase in their use for other agencies such as the Department of Energy and the EPA. Therefore, future research could determine what cost and time savings have resulted from the use of these contracts. This paper has suggested that the use of the TERC at the Norwood site has allowed the remediation to progress in a timely manner and could potentially save money. But it still remains to be determined whether or not there will be any cost savings on the site. Arguably the reimbursable contract with a fixed-fee does not give the incentive to the contractor to keep down the costs that exists in a competitively bid lump sum method. So future research could analyze costs of projects administered under the TERC to determine if the costs and time savings were realized.

The Massachusetts Contingency Plan and the Use of the Licensed Site Professional

Some states have taken on the responsibility to speed cleanups on their own by removing some of the bureaucracy that has plagued federally-driven sites. In Massachusetts, this effort to find a better way to regulate contaminated sites has led to the Massachusetts Contingency Plan. This plan adopted in July, 1993 is the process in which Massachusetts regulates the cleanup of hazardous waste sites. The "center of gravity" of the burden to ensure technical accuracy and protection of public health has been shifted away from the public sector agencies such as the EPA or the Mass. Department of Environmental Protection (DEP) and towards a select, publicly recognized class of practitioners called "Licensed Site Professionals".[86] A LSP must be an experienced professional in the field of hazardous waste site assessment, cleanup and

[86]Campion, Jack and Catherine Walsh. "The Massachusetts Contingency Plan: The Promise of Privatization of Hazardous Waste Site Management." Camp Dresser and McKee information paper, 1994.

removal, must have at least five years experience conducting and overseeing assessments, removals and cleanups of sites (seven years without the appropriate degree), a suitable technical background and good moral character.[87]

Massachusetts instituted the LSP program in order to take the responsibility for the oversight of the cleanup away from the government and put it on the hands of the private sector. This idea is in response to the problems experienced in the Superfund where it would take the EPA months and years to hand down a decision on a best method for cleanup. With the LSP, the professionally licensed individual can make an assessment and begin the cleanup immediately, taking full responsibility for the outcome. An investigation into the MCP and the use of the LSP could provide more examples of how to remediate a site more efficiently.

Collection of Data to Improve Remediation

As the country gains more experience with remediation, there should not be as great a need to investigate a site for the best method. The EPA has a program to promote the use of innovative technology with the hope of developing technologies that can dramatically improve the way sites are cleaned up. But in the near future, a contractor should be able to collect information from past projects that gives the best solution to a given contaminant. Future research could analyze the applicability of this type of approach and whether or not it is something that is used in remediation.

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[87]"Board of Registration of Hazardous Waste Site Cleanup Professionals: Information Sheet." January 1993.

BIBLIOGRAPHY

Alm, Alvin L. and Jean Somers. "Ten Ways to Get Cleanups Moving Now", Special Advertising Section in ENR, June 6, 1994, p. E40-E43.

Ayers, Kenneth W., Amy R. Halloran, and Dikran Kashkashian. "Remedial Action Bids and Cost Estimates", *Hazardous Waste Conference*, May 1991, p. 420-438.

Contract Flexibility Gives Firms a Competitive Edge", *Environmental Business Journal*, Volume VII, No. 8, August 1994, p. 5.

Cravens, Paul B. "A Case Study of Change Orders at a Superfund Site", Hazardous Waste Conference, May 1991, p. 376-390.

"Discernible Shifts in Remediation Markets", *Environmental Business Journal*. Volume VII, No. 8, August 1994, p. 1-3.

Duvel, William A. "Controlling Environmental Cleanup Costs", Hazardous Materials Control, March/April 1992, p. 34-35.

Erickson, Stu. "District Issues Four TERCs Totaling $650 Million", The Omaha Quarterly, Volume 18, No. 1, Winter 1994, p. 14-16.

Erickson, Stu. "TERC Adds Weapon to Contracting Arsenal", Omaha Quarterly, Volume 17, No. 3, Summer 1993, P. 6-27.

Evans, Gordon M. and Jim Peterson. "Cost Estimating Systems for Remedial Action Projects", Hazardous Waste Conference, May 1991, p. 399-402.

"Factors for Success Increase in Highly Competitive Market", *Environmental Business Journal*, Volume VII, No. 8, August 1994, p. 4-5.

Fairneny, Christine. "Project Management Tools." Notes from lecture, April 28, 1995.

Fite, Mark J. "Change Orders Can Ruin Your Day: An Analysis of Construction Change Orders in the Region 6 Superfund Program", *Hazardous Waste Conference*, May 1991, P. 409-419.

Guide to the Project Management Body of Knowledge (PMBOK), Project Management Institute, 1994.

Johnston, Paul. "Total Environmental Restoration Contracts", Hazardous Materials Control, May/June 1993, p. 36-39.

Longest, Henry L. "The Superfund Accelerated Cleanup Model: Moving Forward, *Hazardous Materials Control*, March/April 1993, p. 28-30.

Miller John B. "Transaction Costs in Superfund Cleanup as a Function of Joint Liability: Two Proposals for Change", *Federal Contracts Report*, October 4, 1993.

OHM Corporation, *1994 Annual Report.*

OHM Corporation. *1993 Annual Report.*

OHM Corporation. *1992 Annual Report.*

OHM Corporation. "Standard Operating Procedures for the Total Environmental Restoration Contract", November 18, 1994.

Parvin, Jean. "The New Realism: Juggling Priorities for a Cleaner America", Special Advertising Section in *ENR*, June 6, 1994, p. E3-E5.

Parvin, Jean. "New Realities, New Strategies", Special Advertising Section in ENR, June 6, 1994, p. E5.

Pollis, Gerald M. *Information Paper: Total Environmental Restoration Contracts*, January 25, 1995.

Rubin, Debra K. "Ohio Cleanup Firm is Heartland's Cash Crop", *ENR*, July 4, 1994, p. 22-26.

Rubin, Debra K. and Steven W. Setzer. "The Superfund Decade: Triumphs and Troubles" *ENR*, November 26, 1990, p. 38-44.

Securities and Exchange Commission. *Form 10-K: OHM Corporation*, File Number 1-9654, for year ending December 31, 1993.

Shooter, Douglas. and C. Stow Walker. "Remediation Services Market Study", *National Environmental Journal,* January/February 1993, p. 24-29.

Schroeder, Brett R. "Cost Inaccuracies in Superfund Projects: Strategies for Building Better Estimates", Superfund Conference, December 1992, p. 236-240.

Spreizer, Gisella M. and Susan S. Suthersan. "Integrated Remediation Approaches: Combining Technology, Risk Assessment. and Environmental Statistics", *National Environmental Journal*, May/June 1993, p. 40-48.

Tunnicliffe, Peter W. and Thomas Thurton. "The RCRA Reauthorization: Logic Must Be Reinstated into the Process", Special Advertising Section in *ENR*, Volume 228, No. 25, June 22, 1992, p. E-33-E-34.

U.S. Army Corps of Engineers. *Management Plan for the Total Environmental Restoration Contract,* September 17, 1993.

U.S. Army Corps of Engineers. Missouri River Division. *Acquisition Plan for the Total Environmental Restoration Contract*, Revision No. 10, Jan 7, 1993, Amended Jan 25, 1993.

U.S. Army Corps of Engineers. *Request for Proposals, New England Total Environmental Restoration Contract*, June 28, 1993.

U.S. Army Corps of Engineers. *TERC Delivery Orders: Planning, Issuance, and Administration*, March 1994.

U.S. Army Corps of Engineers. *TERC Delivery Order #7*, June 1994.

U.S. EPA, *Fact Sheet: Norwood PCB Superfund Site - Countdown to Cleanup*, Spring 1994.

U.S. EPA, Office of Solid Waste and Emergency Response. *Presumptive Remedies: Policy and Procedures*, Report 540-F-93-047, September 1993.

U.S. EPA, Office of Solid Waste and Emergency Response. Superfund Revitalization: Measures of Success, Report 540-R-93-084, January 1994.

U.S. EPA, Region I. *Record of Decision Summary: Norwood PCB Superfund Site, Norwood, Massachusetts,* September 29, 1989.