**ENVIRONMENTAL
RESTORATION AND
WASTE MANAGEMENT
COST ASSESSMENT TEAM**

(EM/CAT)

**COST ESTIMATING
HANDBOOK FOR
ENVIRONMENTAL
RESTORATION**

FOREWORD/ACKNOWLEDGEMENTS

This Handbook is the product of the U.S. Department of Energy's (DOE) Environmental Restoration and Waste Management Cost Assessment Team (EM-CAT). The EM-CAT is composed of representatives from the major operating sites in the DOE complex and includes a mix of cost engineers and environmental professionals. The Office of Project Management and the Hazardous Waste and Remedial Actions Division* under the Assistant Secretary for Defense Programs originated the activity, coordinated the EM-CAT, and participated in it's work.

The Handbook is a "living document." As experience is gained with remediation, per se, and with estimating remediation activities, the Handbook will be expanded, clarified, and updated. (Recommendations can be made to IPA, Inc.)

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CHAPTER 1

1.0 INTRODUCTION

Environmental restoration (ER) projects have presented the DOE and cost estimators with a number of properties that are not comparable to the normal estimating climate within DOE. These properties include:

- o An entirely new set of specialized expressions and terminology.
- o A higher than normal exposure to cost and schedule risk, as compared to most other DOE projects, due to changing regulations, public involvement, resource shortages, and scope of work.
- o A higher than normal percentage of indirect costs to the total estimated cost due primarily to record keeping, special training, insurance, liability, and indemnification.
- o More than one estimate for a project, particularly in the assessment phase, in order to provide input into the evaluation of alternatives for the cleanup action.

While some aspects of existing guidance for cost estimators will be applicable to environmental restoration projects, some components of the present guidelines will have to be modified to reflect the unique elements of these projects.

1.1 Purpose

The purpose of this Handbook is to assist cost estimators in the preparation of environmental restoration estimates for Environmental Restoration and Waste Management (EM) projects undertaken by DOE. The DOE has, in recent years, seen a significant increase in the number, size, and frequency of environmental restoration projects that must be costed by the various DOE offices. The coming years will show the EM program to be the largest non-weapons program undertaken by DOE. These projects create new and unique estimating requirements since historical cost and estimating precedents are meager at best.

It is anticipated that this Handbook will enhance the quality of cost data within DOE in several ways by providing:

- o The basis for accurate, consistent, and traceable baselines.
- o Sound methodologies, guidelines, and estimating formats.
- o Sources of cost data/databases and estimating tools and techniques available to DOE cost professionals.

The result will be greater comparability between estimates, reduced risk to projects from under/over estimating, expanded communication of cost drivers, and improved capability to successfully meet budget validation requirements.

1.2 Background

This Handbook is the result of a combined effort by members of the EM Costing Assessment Team (EM-CAT), reference Appendix C. The team objectives were:

- o To review existing cost estimating policy and guidance related to environmental restoration.
- o To evaluate the requirements for environmental restoration cost data by Headquarters, field offices, and contractors.

- o To assess the need for change and/or redirection in the means, methods, and policies for cost estimating/data gathering on environmental restoration projects.
- o To forward recommendations that would increase the effectiveness of DOE in areas of ER project cost management, control, and execution.
- o To provide a focal point for the dissemination of costing data, methodologies, and techniques.

1.3 How to Use the EM-CAT Handbook

This Handbook is not intended to be a comprehensive guide for cost estimating in the DOE complex. Beyond a certain level of detail, standard cost estimating practices should be employed. For environmental restoration projects, this Handbook provides guidance down to the sub-category level (identified as Level 6 in the WBS outlined in Chapter 5). In other cases (e.g., decontamination and decommissioning projects), this Handbook simply illustrates these projects at higher WBS levels but does not provide any specific guidance on estimating these classes of projects. If there are any questions on estimating approaches or procedures not addressed in this Handbook, please refer to standard DOE guidelines.

This document has been designed with the cost estimator end-user in mind. Consequently, various sections of the Handbook may be more appropriate for certain tasks confronting the estimator. Below is a brief set of guidance on utilizing the Handbook based on the end-user's needs:

Creating a New Cost Estimate -- Most, if not all, of the Handbook is relevant to an estimator generating a new cost estimate. Chapter 2 will assist you in placing your estimate in the context of other environmental restoration project cost estimates. Chapter 3 provides a list of elements that should form the basis of the estimate. Specific guidelines for building an estimate are found in Chapter 4. Chapter 5 supplies a model work breakdown structure (WBS). Guidance on estimating a project contingency can be found in Chapter 6 while similar guidance for escalation is provided in Chapter 7.

For additional information, several sample estimates are included in Appendix D.

Reviewing a Cost Estimate -- While most of the Handbook will be useful for reviewing an estimate, certain chapters will provide some helpful information. First, Chapter 3 can be useful to make certain the estimate has all of the requisite components. A quick review of Chapter 5 will indicate if the estimate follows the prescribed WBS. Given the large degree of uncertainty in environmental restoration projects, an examination of Chapter 6 (Contingency) is also appropriate.

Identifying Additional Resources for Generating Cost Estimates -- Three sections of the Handbook contain information on additional sources of information. Chapter 9 lists sources of data for building estimates. Chapter 10 surveys available computer-based tools for generating estimates. Finally, a bibliography is provided in Appendix E.

Understanding the Evolution of an Environmental Restoration Project -- Since regulations play a major role in determining the project stages and milestones, specific guidance on these regulations is likely to be more helpful than the Handbook. However, Chapter 2 includes some information on project stages as they relate to different types of estimates and Chapter 4 provides some background on major project elements. Appendix D contains certain examples that may also be helpful.

A great deal of relevant information on program management can be found in the latest draft of the Environmental Restoration On-Site Remediation Program Management Plan (ER/ORP-100). The purpose of this Plan establishes the On-Site Remediation Program Management approach. Throughout the EM-CAT Handbook, other relevant documents are identified and cited in the bibliography (Appendix E). As other related documents are developed for the EM Program, they will be referenced in future versions of this Handbook.

1.4 Other Information

Throughout this Handbook, several different terms are used to describe an environmental restoration project. A project is referred to in the Handbook by its regulatory designation. For example, a project under the CERCLA/SARA program is called an "operable unit." A remediation task relates to the activities budgeted by the Activity Data Sheets (ADS) and generally is divided into assessment and cleanup tasks.

Acronyms may be found in Appendix A and a glossary in Appendix B.

CHAPTER 2

2.0 TYPES OF ESTIMATES

Unlike most capital projects that have well established points at which cost estimates are generated, there is little agreement in the environmental community on estimate types for assessment and remediation projects. Below are several factors that distinguish the nature of estimates at different stages throughout the course of an environmental restoration project:

- o **Regulations Often Determine the Schedule for Generating Estimates:** To a large extent, the regulatory process, not necessarily the nature of the work, drives the timing for the generation of estimates. The regulations establish several decision points when an estimate of the cost of the project is required. For example, for a remedial action under CERCLA/SARA, estimates are required for all alternatives considered during the feasibility study, an estimate is needed for the Record of Decision (ROD), another estimate usually is generated when design is 30 to 60 percent complete, and an estimate is generated for the construction bid package. The budget cycle and other special review documents (e.g., the 5-Year Plan) add additional estimating demands. Due to the nature of these projects, new estimates also may be required for presentation at public participation meetings.
- o **Environmental Restoration Activities are Often Required to Adhere to Multiple Regulations:** Most, if not all, of DOE's environmental restoration (ER) activities will be required to adhere to guidelines established by different regulatory regimes. Since each regulatory system has its own set of guidance on estimate needs, it will be necessary to overlay the regulatory systems to develop a better understanding of the types of estimates required throughout the course of a project.
- o **The Two Distinct Phases of an Environmental Restoration Project Complicate Estimating Practices:** Unlike standard construction jobs, ER activities have two major components: assessment and cleanup. Consequently, different types of estimates are needed for each of these phases. This structure for ER activities causes some confusion when it is compared to existing project management systems. For example, it is possible to crosswalk DOE Order 4700.1 with the cleanup stage of an ER activity. However, it is almost impossible to make the same comparison between DOE Order 4700.1 and the remedial assessment stage. During assessment, the major product is a paper study on the extent of the contamination and a list of potential alternatives.
- o **Cost Estimates will be Required Even Though Little is Known about the Nature of the Contamination and the Technology for Cleaning Up the Site has not been Identified:** Perhaps the most challenging activity confronting estimators throughout the complex is the fact that many planning estimates will be generated on the basis of unknown and/or highly uncertain information. In fact, estimates will be required for ER activities where little is known about the general scope of the project. Assessments are particularly challenging in that an estimate must be generated for a job where the goal is to investigate the nature of the contamination. These assessment activities tend to look like research and development projects rather than capital projects.

Even though there is some debate over the specific steps that a DOE ER activity will follow, this section will describe several different types of cost estimates likely to be developed during the course of an environmental restoration project. Throughout this Chapter, the regulatory terminology for the CERCLA/SARA and RCRA programs is used to provide a baseline for discussing estimate types. Further comparisons of major regulatory programs are discussed in Chapter 4 and illustrated in Figure 4-1. It may be helpful to reference the regulatory crosswalk provided in Figure 4-1 when reading this Chapter. All of the figures in this Chapter reference CERCLA/SARA terminology; information in Chapter 4 can link these terms with other regulatory guidelines. This section has been divided into three parts to reflect estimates developed for the two major phases of an ER project (assessment and remediation) and a third section for estimates applicable to either stage. Each estimate type is linked with the relevant project phase. In addition, the definition of each estimate type will include a discussion of the minimum requirements for estimate content. All estimates shall be prepared using the project

Work Breakdown Structure (WBS) (see Chapter 5). It is important to note that any one of these types of estimates may become the first baseline estimate.

2.1 Assessment Stage Cost Estimates

During the assessment stage of an ER project, detailed information is gathered about the nature of the contaminated area and a list of feasible alternatives for remediating the site is developed. The assessment stage concludes with the identification of a specific alternative to be implemented at the site. Under CERCLA/SARA, this stage includes the preliminary assessment/site inspection (PA/SI) and the remedial investigation/feasibility study (RI/FS). A corrective action under RCRA considers the RCRA Facility Assessment (RFA), the Corrective Measures Study (CMS) and the RCRA Facility Investigation (RFI) to be the major elements of the assessment stage.

There are three major types of assessment cost estimates: planning estimates, preliminary estimates, and detailed estimates. Figure 2-1 identifies when these estimates are likely to be generated for CERCLA/SARA projects. In the early stages of a project, planning estimates for the cost of the assessment work will be required. Planning estimates are likely to be generated during the preliminary assessment stage of a CERCLA/SARA project. After the completion of the PA/SI, a preliminary estimate will be generated with the additional information gathered during the PA/SI. With the completion of the work plan for the RI/FS, detailed estimates of the cost of assessment will be available. Each estimate type is discussed in detail below.

2.1.1 Planning Estimates

As a result of planning documents and preliminary budget requests, early estimates will be required for the cost of assessment work on ER activities. In particular, cost information for inclusion in the Environmental Restoration and Waste Management 5-Year Plan will fall under this category unless a more definitive estimate is available. All that may be known about an activity at this estimate stage is its location, likely contaminants, and prior or current use of the site. Details on the scope of the remedial investigation (RI) are not available. Analogy, simple cost estimating relationships, and more sophisticated parametric tools are utilized to ascertain planning estimates. The WBS outlined in Chapter 5 should be followed in as much detail as is available. The contingency for this estimate requires more attention because of the large degree of uncertainty at this stage. Formats established for building a contingency estimate (Chapter 6) and estimating escalation (Chapter 7) should be followed. Since information about the scope of the investigation is often scarce, all relevant data used in building the estimate should be included in the basis of the estimate (see guidelines in Chapter 3).

2.1.2 Preliminary Estimates

A preliminary estimate for assessment work is usually developed immediately following the preliminary assessment of the activity. A formal work plan estimate is prepared in parallel with the development of a detailed plan for assessing a remediation site. At this point in the process, some preliminary information about the site is available through the preliminary assessment and/or site inspection. In addition, unit cost figures often can be applied to sampling plans, well drilling maps, laboratory analysis plans, and other standard investigation activities. A level of effort measure by personnel categories can be an effective means of costing assessment activities. All cost figures shall be escalated to the scheduled midpoint of the activity being estimated using the escalation rates established for environmental restoration in Chapter 7. Contingency shall be estimated on the basis of guidance provided in Chapter 6.

Estimate Types for Costing the Assessment Phase

(Using CERCLA/SARA Terminology)

Figure 2-1

2.1.3 Detailed Estimates

Once assessment has begun, more definitive estimates can be developed. A definitive estimate will be required at the start of the remedial investigation (or RFI). In addition, detailed estimates may be generated throughout the course of the assessment activities. One likely point when another detailed estimate may be required is after the completion of the remedial investigation (or RFI) and just prior to or very early in the preparation of the feasibility study (or CMS). While the remedial investigation and feasibility study stages may overlap, most of the field work will be completed before the preparation of the feasibility study can commence. Since the field work will be completed, an estimate with a high degree of confidence can be developed. Historically, the assessment of an ER activity has required several phases. As a result, an estimate falling under this category might be required between assessment phases.

As with the other estimate types, a detailed estimate should include a WBS (see Chapter 5). The contingency estimate should follow the format developed in Chapter 6. All costs should be escalated to the mid-point of the completion of assessment using the guidelines established in Chapter 7.

2.2 Cleanup Cost Estimates

The cleanup stage commences after an alternative has been selected for remediating the site and continues through completion of construction of the remedial alternative. The two dominant components of this stage of an environmental cleanup activity are remedial design and remedial construction. While operations and maintenance of the remedial alternative may be required, they are not included in the cost of the remedial action.¹

Cost estimates are required for the cleanup during the assessment stage even though the remedial technology for the activity has not been determined. At these preliminary stages, estimates for a variety of possible technical alternatives may be requested.

There are several documents required as part of the regulatory process that contain cleanup cost estimates. Under CERCLA/SARA, the feasibility study includes cost estimates for all considered remedial alternatives. The Record of Decision (ROD) generally includes the cost estimate for the selected alternative developed for the feasibility study. A Pre-Design Report serves as a hand-off document between assessment and cleanup. It includes all design information developed for the selected alternative during the assessment stage and may include an updated cost estimate. The next formal document containing an estimate is developed for the construction bidding process. At this point, 60-90 percent of the design has been completed. A timeline outlining the CERCLA/SARA steps and the estimate types discussed below is shown in Figure 2-2.

For cleanup projects, there are four major types of cost estimates: planning estimates, feasibility estimates, preliminary estimates, and detailed estimates. These estimate types are discussed in detail below.

2.2.1 Planning Estimates

Like planning estimates for the assessment stage, planning estimates for cleanups are often requested for budgetary purposes or for inclusion in planning documents. In most cases, these estimates will be needed for inclusion in the Environmental Restoration and Waste Management 5-Year Plan unless a more definitive estimate has been developed. Since this type of estimate is prepared during the initial part of assessment, only minimal design information, if any, is available. The lack of detailed design information will often preclude the use of detailed estimating techniques and estimates will often rely to some degree on historical data. The source of historical data and the estimating technique used to apply it (such as parametrics) should be clearly documented in the basis of estimate to maintain traceability. Estimates shall be formatted in accordance with

¹ However, some regulations require the development of a net present value cost of project for the entire life of the project.

the environmental restoration cost estimate format shown in Figure 4-2. The contingency estimate shall be prepared in accordance with Chapter 6 of this Handbook. All cost figures shall be escalated to the scheduled midpoint of the activity being estimated (i.e., remedial design, purchase of major equipment, remedial action). Chapter 7 provides more detailed information on calculating escalation costs.

2.2.2 Feasibility Estimates

Feasibility studies prepared during the later part of assessment require cost estimates supported by quantity takeoffs, pricing, and equipment usage for cleanup activities. The design, schedule, and cost estimate developed for a feasibility study are all part of the detailed information that supports selection of a remediation method. The estimate and schedule also form the first formal baseline for performance measurement for the cleanup phase against which future developments will be measured and evaluated. The cleanup cost estimate is an important element of this baseline and requires a cost estimate that can provide adequate information for project management decision making.

Evaluations of alternative technical solutions developed during the later stages of assessment are supported by these feasibility estimates. These estimates are included in the feasibility study, from which the alternative employed at the site is selected. The purpose of such estimates is to allow comparison of cost requirements to occur in parallel with the evaluation of technical and regulatory requirements. As such, a feasibility estimate performs two functions:

1. It presents the total estimated cost of each alternative on the basis of the best information available; and
2. It provides a logical, traceable framework for comparing alternatives with each other.

The logical traceable framework is best provided by the WBS. In order to make an accurate comparison, evaluators must have a complete estimate. A properly prepared WBS will facilitate this process (see Chapter 5).

Cleanup costs will be estimated at the lowest level of detail that can be developed within each cost element. For conventional cost elements such as excavation, this will normally consist of quantity takeoffs made on the basis of drawings supplemented with information obtained from calculations and outline specifications. When sufficient detailed information is not available, estimates can be developed on the basis of historical data or engineered standards. Examples of this type of estimating include unit costs based on historical data for items such as temporary facilities and unit quantity standards that relate quantities of one item, such as leak testing, to another item, such as installation labor. Particular care should be exercised when using historical data to prepare estimates so that traceability can be maintained in areas such as indirect cost. Estimates should be carefully documented to avoid double counting or omissions in areas such as overhead, profit, sales tax, and general requirements.

Feasibility estimates shall be supported by a completed basis of estimate prepared in accordance with Chapter 3 of this Handbook. The feasibility estimates will contain a project cost summary, in the format specified by Figure 4-2, and reconcilable to the project WBS. All cost figures shall be escalated to the scheduled midpoint of the activity being estimated (i.e., remedial design, purchase of major equipment, remedial action) using the escalation rates established for ER projects in Chapter 7. The estimate also will include a contingency summary that presents the results of a project-specific contingency analysis.

2.2.3 Preliminary Estimates

After an alternative has been selected for an activity, a more detailed cost estimate than was developed for the feasibility study will be required. This preliminary estimate will have sufficient detail to be used as a project control tool. All major cost elements shall be included in the preliminary estimate. Remedial design cost should be presented as the negotiated contract cost or as the current working estimate. Cost incurred to date, if any,

Estimate Types for Costing the Cleanup Phase

(Using CERCLA/SARA Terminology)

Figure 2-2

should be shown as actual. To the extent that detailed information is available, major items of equipment should be based on the current bill of material and supported by vendor quotes. Project management cost should be based on the cost incurred to date plus the estimated cost to complete. The nature of cost data (actual or estimated) should be properly accounted for in the contingency analysis.

The preliminary estimate will contain a project cost summary in the format specified in Figure 4-2 that is reconcilable to the project WBS presented in Chapter 5. All cost figures shall be escalated to the scheduled midpoint of the activity being estimated (i.e., remedial design, purchase of major equipment, remedial action) using the escalation rates established for environmental restoration.

2.2.4 Detailed Estimates

Definitive design shall include preparation of a detailed estimate made on the basis of all approved engineering data including drawings, specifications, calculations, the schedule, and anticipated method of accomplishment (contracting plan). The format of the detailed estimate shall be the same as that of the preliminary estimate to facilitate baseline management and shall include a cost summary in the format specified in Figure 4-2. It should also include a contingency summary presenting the results of a project specific contingency analysis. Definitive estimates shall be supported by a basis of estimate that has been prepared in accordance with Chapter 3 of this Handbook. Care should be exercised when preparing the definitive estimate to group items into bid packages that correspond with the contracting plan to facilitate bid evaluation. The use of computer aided estimating systems will assist in maintaining traceability between the multiple reporting formats required of cost estimates. All cost figures shall be escalated to the scheduled midpoint of the activity being estimated, i.e., remedial design, purchase of major equipment, and remedial action, using the escalation rates established for environmental restoration projects.

2.3 Estimate Types Applicable to Both Assessments and Cleanups

2.3.1 Government Estimates

All contracts for amounts greater than \$25,000 require Government estimates. This includes contracts for services such as engineering or inspection as well as contracts for purchase of equipment or construction of facilities. These estimates shall be prepared independently and in advance of any bid or solicitation for proposals from contractors or subcontractors. Since Government estimates will be used to determine the reasonableness of contractor bids, the Government estimate shall be prepared in the same format as those bids. This requirement must be included in the instructions to bidders in the form of a recommended cost breakdown that lists all information needed for bid evaluation. In the case of assessment and cleanup contracts, the Government estimate is often based on the detailed estimate.

2.3.2 Current Working Estimates

These estimates are required for cost control on large projects and are conducted periodically throughout the life of the project. It is necessary that working estimates be kept under constant review to assure that they reflect the latest cost and design data available, the estimated cost to complete, the allowance for contingency based on detailed contingency analysis, and the uncertainties remaining under the project.

2.3.3 Independent Cost Estimates

An independent cost estimate (ICE) is a documented cost estimate that has the express purpose of serving as an analytical tool to validate, crosscheck, or analyze estimates developed by proponents of a project. An independent cost estimate also serves as a basis for verifying cost risk assessments. These estimates may be performed by the Independent Cost Estimating Staff (MA-202.2) in support of key decisions by the Under Secretary. When they are initiated by an Assistant Secretary, Program Manager, Project Manager, or some other advocate as a check against the project estimate, they are called "check estimates."

CHAPTER 3

3.0 BASIS OF THE ESTIMATE

A basis of the estimate should be written for each task explaining how the estimate was developed. A written synopsis should accompany the estimate and should be permanently filed in the project files. At a minimum, the following major topics should be covered:

3.1 Task Description

Provide a brief description of the task the estimate covers. Reference other documents that provide a more detail description of the task. If the work is a smaller component of a larger project (e.g., an operable unit), also describe the larger project.

3.2 Project Work Breakdown Structure

Provide a figure showing the work breakdown structure (WBS) (refer to Chapter 5). The level of detail provided in the WBS should be at the same level the estimate is prepared.

If the WBS described in this Handbook is not used, it must be delineated in detail in the basis of the estimate so that other readers can follow the estimate.

3.3 Summary Task Schedule

Provide a figure(s) showing the task schedule. The schedule should be in sufficient detail to show duration in quarters for each participant's major project task. The estimated task cost should be projected over the duration of the schedule.

3.4 Basis of the Cost Estimate

The information in this section is intended to provide an understanding of the methodology used in developing the cost for the task. Each major cost category should be addressed in a separate paragraph with a narrative that explains how the cost was derived. All ground rules and assumptions used in developing the estimate should be documented (e.g., type of contract, cleanup technology, extent and nature of the contaminated media, etc.).

Explanations for material and labor cost should be covered independently. A separate paragraph(s) should be used to explain wage rates contained in the estimate. If crew rates are used then: (1) define the crew; (2) state whether benefits are included in the rate; and (3) identify where FICA payroll taxes and Workman's Compensation Insurance are contained in the estimate.

3.5 Escalation

List the escalation rates used to escalate the base cost and the method of escalation applied. Indicate the pattern of the disbursement schedule to which the escalation was applied.

3.6 Summary of Accomplishments

Describe what work will be accomplished by the various task participants.

3.7 Contingency Analysis

Explain how the contingency for the task was calculated (refer to Chapter 6). Provide a detailed justification for the amount of contingency. Explain use of contingency to date.

3.8 Cost and Obligation Plan and Rationale

Explain the rationale used to develop the task cost and obligation schedules. In addition to normal documentation, record, for example, long lead procurements, special studies, a particular construction or cleanup strategy, anticipated technology developments, etc.

CHAPTER 4

4.0 GUIDELINES FOR DEVELOPING COST ESTIMATES

This chapter provides guidelines for estimating costs in each of four categories: Assessment, Cleanup Design, Cleanup Action, and Activity and Program Management. These categories correspond to major classes of work within a typical environmental restoration project. As currently structured in the WBS (see Chapter 5), Environmental Restoration activities are categorized as either assessment or cleanup. Assessment includes a broad array of engineering and scientific studies as well as activity management that occurs prior to cleanup design. Cleanup includes cleanup design, cleanup action, and activity management. A separate activity, distinct from cleanup activities, will be established for program management at various levels in the WBS. A comparison of terminology is provided in Figure 4-1, which acts as a reference between environmental terminology and construction terminology. This crosswalk is not meant to establish direct equivalence but only to assist cost estimators in familiarizing themselves with environmental terms.

4.1 General Guidelines for Developing Cost Estimates

As with any estimating task, several general guidelines should be followed. First, the estimating task should be defined and planned. Chapter 2 provides some insight into estimate types; while Chapter 3 indicates the type of information that will form the basis of the estimate. Second, the work breakdown structure outlined in Chapter 5 should be used to organize cost data for integration with other parts of the project management system. Third, the necessary cost and cost-related data should be collected, evaluated, and applied. Data resources are discussed in Chapters 9 and 10. Fourth, the proper estimating methods should be used. At early estimate stages, parametric techniques are likely to be the most appropriate method because design information will be inadequate for other estimating methods. Bottoms-up approaches will be more appropriate for later estimates. Finally, the estimate should be documented in enough detail so that it can be reviewed, evaluated, and used in the decision-making process. The Estimator's Checklist described in Chapter 8 provides guidance on reviewing the scope of work for ER projects. Chapter 6 and Chapter 7 should be followed to properly apply contingency and escalation, respectively.

Each cost estimate shall be summarized in the format shown in Figure 4-2. The formal Basis of the Estimate described in Chapter 3 and the appropriate additional summary estimates for Assessment (Figure 4-3), Cleanup (Figure 4-4) and/or Program Management (Figure 4-5) shall, as a minimum, accompany the estimate to facilitate review and evaluation. These formats will also provide the information needed for integrating the cost estimate with the budgeting system (the Five Year Plan), the scheduling system, the project management system (the Work Breakdown Structure), and the reporting system. The cost estimate format includes funding requirements for the first five years of each task and this information will be used as input to the Five Year Plan.

4.2 Guidelines for Assessment Estimates

Assessment is the technical activity of an engineering, scientific, or regulatory nature that is required to establish scope, meet regulatory requirements, or evaluate alternatives for a task. This will include PA/SI, FI/CMS, RI/FS and any other pre-cleanup design activity performed in support of a particular activity.

The environmental restoration program scope will include a large number of engineering and scientific studies that address design, technical, and regulatory issues not encountered on conventional construction projects. These have been grouped into legal categories which establish the general requirements for each.

National Environmental Policy Act (NEPA)
Environmental Assessment (EA)
Environmental Impact Statement (EIS)

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
Preliminary Assessment/Site Inspection (PA/SI):
Cleanup Investigation/Feasibility Study (RI/FS):

Resource Conservation and Recovery Act (RCRA)
Facility Assessment
Facility Investigation/Corrective Measures Study (FI/CMS)

The above assessment activities are included in the scope of the environmental restoration program and shall be directly charged to the program. Guidelines for estimating the cost of each will be presented this chapter. It is possible that these investigations will result in a determination that no cleanup is necessary. These studies are to be directly charged to the program even when no cleanup action is undertaken. The need for these engineering and scientific studies and the scope of each are determined by a combination of a project's technical needs and the requirements of state and Federal laws and regulations. Relevant issues to be addressed include scope, cleanup technology, public health risk, and regulatory compliance measures. The level of detail required for feasibility studies will often exceed that encountered in the conceptual design phase of conventional construction projects. The true scope of the cleanup action will not be known with any degree of accuracy until these studies are completed and accepted by DOE, and Federal and state regulatory agencies.

4.2.1 Environmental Assessments (EAs)

Environmental Assessments are conducted to meet the requirements of the National Environmental Policy Act (NEPA). The objective of an EA is to determine if a proposed action will have a significant impact on the environment and to assess that impact. If an EA results in a finding of no significant impact (FONSI), a notice is published in the Federal Register to that effect. If there is a significant impact or if there are objections to the FONSI, an EIS may be required. An EA can include the following elements of work:

- (a) Planning and coordination of the EA process in which potential sources of data are identified and the scope of the proposed action is reviewed.
- (b) Inventory of natural, human and cultural resources based on existing sources of information. Typical elements of the resource inventory include geology, hydrology, vegetation, wildlife, threatened and endangered species, and air quality, land use (existing and planned), visual characteristics, socioeconomic character, and acoustic conditions. Cultural resources include archaeological sites, historical sites, site with religious or social significance, and other structures or areas with cultural significance.
- (c) Impact assessment and mitigation planning in which the proposed action is evaluated to determine the impact on the resources identified in the inventory. Appropriate mitigation measures are identified where it is possible to make adjustments in the proposed action which reduce or eliminate impacts.
- (d) Participate in agency reviews of the EA and respond to questions and comments.
- (e) Prepare an EA including decision documents.

When the NEPA process is successfully concluded with an EA, other environmental permitting actions may follow such as preparation of a Prevention of Significant Deterioration (PSD) permit under the Clean Air Act. If a FONSI cannot be obtained, an EIS is required.

Comparison of Terminology for an Environmental Restoration Project

Figure 4-1

**ESTIMATE FORMAT FOR
ENVIRONMENTAL RESTORATION
COST ESTIMATE/FUNDING SUMMARY**

Task Title:
Task Number:
Operations Office:
Installation:
Regulatory Designation:
Assessment/Cleanup or Program Management:
Estimate Type: (i.e., Planning/Preliminary/Detailed, etc.)
Estimate Date:
B & R Code:

**FUNDING REQUIREMENTS
(As Spent Dollars X 1000)**

Fiscal Years*

Prior Years	1992	1993	1994	1995	1996	Sub Total	1997- 2000	2001- 2005	2006- 2010	2011- 2015	2016- 2020	Total Estimated Cost
(TEC)												
\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$

*Provide yearly funding for next five years from estimate date. Adjust fiscal year as required.

Figure 4-2

ENVIRONMENTAL RESTORATION ASSESSMENT

Task Title:
Task Number:
Operations Office:
Installation:
Regulatory Designation:
Estimate Type: (i.e., Planning/Preliminary/Detailed, etc.)
Estimate Date:
B & R Code:

*CATEGORY		AS SPENT DOLLARS X 1000	
Preliminary Assessment (PA or RFA)			Total
Inspection			Total
Surveillance and Maintenance			Total
Characterization (RI or RFI)			Total
Work Plan Preparation	Subtotal		
Well Drilling	Subtotal		
Sample Analysis	Subtotal		
Alternative Evaluation			Total
Reports (FS or CMS)	Subtotal		
NEPA Review	Subtotal		
ROD	Subtotal		
Task Management			Total
Standard Equipment			Total
	Subtotal		
Contingency			Total
Total Estimated Cost	Grand Total		\$
*Sub-categories may vary - dependent upon task			

Figure 4-3

**ENVIRONMENTAL RESTORATION
CLEANUP**

Task Title: Cleanup of XYZ Project
Task Number: 61277
Operations Office:
Installation:
Regulatory Designation: CERCLA
Estimate Type: Preliminary
Estimate Date: 7/90
B & R Code: EW-20-10-10

<u>CATEGORY</u>	YEAR OF EXPENDITURE DOLLARS X 1000	
Remedial Design		8,642
Preliminary Design	1,319	
Definitive Design	3,077	
Construction Management	4,246	
Land and Land Rights		0
Remedial Action (CM or RA)		43,831
Site Preparation	3,136	
Construction of Cap	26,986	
Gas Collection and Treatment Facility	5,818	
Groundwater Collection and Pretreatment Facility	3,393	
Laboratory Facilities	4,498	
Task Management		438
Standard Equipment		2,191
Contingency		14,985
Total Estimated Cost		70,087

Figure 4-4

**ESTIMATE FORMAT FOR
ENVIRONMENTAL RESTORATION
PROGRAM MANAGEMENT**

Operations Office:
Installation:

*CATEGORY	YEAR OF EXPENDITURE DOLLARS X 1000
Labor	Total
Materials/Supplies	Total
Facilities	Total
Equipment	Total
Computer Time	Total
Communications	Total
Travel	Total
Other	<u>Total</u>
	Subtotal
Contingency	Total
Total Estimated Cost	<u>Grand Total</u>

*All categories may vary between installations.

Figure 4-5

4-7

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4.2.2 Environmental Impact Statements (EISs)

Environmental Impact Statements are prepared to meet the requirements of the NEPA whenever an EA does not result in a FONSI. The objective of an EIS is to evaluate any major Federal action that is proposed which has the potential for significant environmental impact and to provide a forum for a public decision making process regarding the action. An EIS can include the following elements of work:

- (a) EIS scoping in which the general technical approach is agreed upon and the public involvement program is initiated. Potential sources of data are identified and the scope of the proposed action, as well as any known alternatives, are reviewed.
- (b) Inventory of natural, human and cultural resources based on existing sources of information. Typical elements of the resource inventory include geology, hydrology, vegetation, wildlife, threatened and endangered species, and air quality, land use (existing and planned), visual characteristics, socioeconomic character, and acoustic conditions. Cultural resources include archaeological sites, historical sites, site with religious or social significance, and other sites with cultural significance.
- (c) Impact assessment and mitigation planning in which the proposed action is evaluated to determine the impact on the resources identified in the inventory. Appropriate mitigation measures are identified where it is possible to make adjustments in the proposed action which reduce or eliminate impacts. Alternatives to the proposed action, including "no action" are considered to evaluate the impact on the environment. The impact of the proposed action is compared to the impact of the other alternative.
- (d) Preparation of a draft EIS and distribution of that report to all interested parties including elected officials, citizen groups, and the public.
- (e) Participate in agency reviews and public hearings regarding the draft EIS and respond to questions and comments.
- (f) Preparation of a final EIS including all comments and the responses to those comments.
- (g) Preparation of decision documents required for a Record of Decision (ROD).

In addition to the cost of an EIS, estimators must consider the impact on schedule. An important consideration in this regard is the possibility of conducting the EIS in parallel with other activities. When allowed, conducting the EIS in parallel with design may save time, but if the EIS produces changes in the proposed action, redesign may be required.

When the NEPA process is successfully concluded with an EIS, other environmental actions may follow such as preparation of permits.

4.2.3 Preliminary Assessment/Site Inspection (PA/SI)

PA/SI is the first phase of work for sites being remediated under CERCLA. The objective of this effort is to identify potential release sites for future study and to rank the hazard according to an EPA methodology called the Hazard Ranking System (HRS). PA/SI includes the following elements of work:

- (a) Review of existing data concerning past operating practices including waste disposal, operations involving potentially hazardous materials, and spills or similar incidents.
- (b) Review of existing data concerning the natural setting such as geology, hydrogeology, surface water, flora, and fauna.
- (c) Analysis of existing data to assess completeness and determine if there is a need for sampling.

- (d) Site visit to confirm site location and relationships with major features.
- (e) Limited sampling and analysis where warranted.
- (f) Evaluation of the hazard posed using the Hazard Ranking System.
- (g) Preparation of a PA/SI report.

4.2.4 Remedial Investigation/Feasibility Study (RI/FS)

RI/FS is the investigation phase of assessment under CERCLA. During RI, quantitative information is collected to characterize the site. Investigation is followed by Feasibility Studies in which alternative methods of cleanup are developed, compared, and preferred method selected to implementation. RI/FS ends when a Record of Decision is reached.

Remedial Investigation can include the following elements of work:

- (a) Review of information collected in the PA/SI and applicable regulations.
- (b) Develop an RI/FS work plan including a sampling and analysis plan, a quality assurance project plan, a health and safety work plan.
- (c) Field sampling and laboratory analysis.
- (d) Evaluate data from field sampling and data analysis.
- (e) Preparation of risk assessment reports including identification of source terms, identification and analysis of pathways and exposure scenarios, identification of receptors, and toxicological assessment.

FS can include the following elements of work:

- (a) Screening of cleanup technologies for suitability.
- (b) Screening of process options for cleanup considering waste character, site conditions, regulatory considerations, and other factors.
- (c) Conduct an endangerment assessment.
- (d) Develop and evaluate alternatives for cleanup including preparation of conceptual designs, schedules and feasibility estimates.
- (e) Conduct treatability studies to establish the effectiveness of selected treatment alternatives.
- (f) Prepare a feasibility study report presenting the results of the FS including the results of: cleanup technology screening, process options evaluation, alternative evaluation, regulatory review, and treatability studies.
- (g) Respond to comments from regulatory agencies and the public.
- (h) Prepare a Record of Decision (ROD).

4.2.5 Facility Assessment

A RCRA Facility Assessment (RFA) is the first step undertaken at a suspected hazardous waste site that is regulated under RCRA. The objective is to review operations and identify potential sources of release for further investigation. An RFA can include the following elements of work:

- (a) Develop an FA workplan submit the plan to regulatory agencies for comments, and incorporate comments.
- (b) Review of historical data concerning present and past operations including any known spills or other unusual events.
- (c) Identify all solid waste management units (SWMUs) on the site.
- (d) Conduct technical investigations necessary for the identification of Potential for an Occurring or Past Release (POPR).
- (e) Preparation of a POPR report.
- (f) Identify the need for interim corrective measures to contain or eliminate sources of continuing releases.

4.2.6 Facility Investigation/Corrective Measures Study (FI/CMS)

A Facility Investigation under RCRA is comparable to a Remedial Investigation under CERCLA. The objective of this effort is to characterize the natural environment, the nature of any hazardous materials that may be present, and identify technologies that will be needed to implement corrective measures. A RCRA Facility Investigation can include the following elements:

- (a) Develop an FI workplan, submit the plan to regulatory agencies for comments, and incorporate comments. The work plan typically includes such elements as data management, health and safety and project management.
- (b) Field investigation, analysis, and research needed to develop a complete description of the regional setting including climatic conditions.
- (c) Field investigation, sampling, modeling, and analysis required to characterize the extent of any release of hazardous material that may have occurred.
- (d) Field investigation sampling, modeling, and analysis required to describe the site hydrogeology, geology, and soil conditions, and surface water hydrology.
- (e) Perform a health risk analysis including quantification of source terms, identification and evaluation of pathways, identification of receptors, and toxicological evaluation of dose response relationships for the affected populations.
- (f) Develop a community relations program and implementation of elements of that plan consistent with plan requirements for the FI.
- (g) Identify potential technologies to be employed in corrective measures.

A Corrective Measures Study (CMS) develops and evaluates alternatives for corrective measure implementation. A CMS can include the following elements of work:

- (a) Develop a CMS workplan including submittal of that workplan to regulatory agencies for review and comment, incorporation of comments.

- (b) Screen cleanup technologies for suitability.
- (c) Screen process options for cleanup considering waste character, site conditions, regulatory considerations, and other factors.
- (d) Develop and evaluate alternatives for cleanup including preparation of conceptual designs, schedules and feasibility estimates.
- (e) Conduct treatability studies to establish the effectiveness of selected treatment alternatives.
- (f) Prepare a Corrective Measures Study report presenting the results of the CMS including the results of: cleanup technology screening, process options evaluation, alternative evaluation, regulatory review, and treatability studies.
- (g) Respond to comments from regulatory agencies and public comments.
- (h) Preparation of a consent order or permit modification.

4.3 Guidelines for Cleanup Estimates

4.3.1 Guidelines for Cleanup Design Estimates

Engineering design for the cleanup will be performed on the basis of the method identified in the Record of Decision (CERCLA) or permit (RCRA). The activities that encompass cleanup design are preliminary design and detailed design, and engineering during construction. The initial phase of cleanup design is referred to as preliminary design because engineering alternatives are being developed and evaluated. In some cases, this phase may be shortened or eliminated entirely if no alternatives can be identified within the scope of the ROD or permit. The second phase of cleanup design is definitive design in which a single alternative is carried to completion.

4.3.1.1 Preliminary Design

In this phase, the design basis documents are defined in greater detail to permit the design process to proceed with the development of alternate concepts within the framework of the approved concept. Preliminary design can include the following elements of work:

- (a) Additional engineering studies, including development of alternative engineering approaches, process design, energy conservation evaluations, maintainability reviews, and analysis or review of health, safety, and environmental aspects of the activity.
- (b) Review of the design basis documents to develop greater detail and to incorporate any design modifications that may result from engineering studies conducted during preliminary design.
- (c) Preliminary design drawings showing the proposed design and any alternates in sufficient detail to establish the design features of each approach and to permit a preliminary estimate to be made of the construction cost.
- (d) Outline specifications for construction and specifications for equipment procurement; identification of long lead time items for advance procurement.
- (e) Preliminary safety analysis report or updated risk analysis, if required.
- (f) Value engineering.

- (g) Construction cost estimate based on the approved design, and other such estimates as required to support the evaluation of alternative designs prepared during preliminary design.
- (h) Preliminary activity schedule based upon information available during preliminary design.

4.3.1.2 Detailed Design

In this phase of the activity, the approved concept developed in Preliminary Design is completed and bid packages are prepared for issuance to cleanup contractors. Detailed Design can include the following elements of work:

- (a) Restudy and redesign work required to incorporate approved changes from the design prepared in preliminary design.
- (b) Final drawings, specifications, waste plans, and construction cost estimates suitable for the performance of the work either from competitive bids or from on-site contractors.
- (c) Analyses of health, safety, environmental, and other project factors that may impact the project and incorporation of the results of those analyses into the bid documents.
- (d) Coordination of all design elements with other activity features such as utility connections, Government furnished equipment, and portions of the activity or related activities being designed by others.
- (e) Attendance and participation as directed in all meetings scheduled for design review or coordination with the DOE, the operating contractor and local regulatory or other public agencies.
- (f) Reaffirm the adequacy of all proposed actions with respect to applicable Federal, State, and local regulations.

4.3.1.3 Construction Engineering

This phase of the activity begins when bid packages are assembled following Detailed Design and consists of engineering services during construction including both office support and field services. The following elements of work are included under office support:

- (a) Review of all vendor drawings and submittals for conformance with the approved design drawings and specifications.
- (b) Review and evaluation of all proposed deviations for the original Detailed Design for conformance with regulatory requirements, codes, and standards.
- (c) Incorporation of all approved as-built deviations from the design drawings in as-built record drawings for delivery to the activity manager. Collect and maintain all construction related records.
- (d) Preparation of cost estimates to establish reasonable amounts of increase or decrease in contract price or schedule caused by design or procedure changes. Evaluate proposals submitted by the cleanup contractor for reasonableness from the perspective of cost and schedule, and make recommendations to the activity manager.
- (e) Expediting the procurement of material and equipment from suppliers, vendors, or fabricators.
- (f) Conduct audits of vendors, suppliers, and subcontractors as required by the Quality Assurance Program Plan.

- (g) Provide additional technical service such as evaluation of site monitoring data, update of risk analyses, review of regulatory correspondence, participate at public meetings, and other similar activities.

The following elements of work are included under field services:

- (a) Furnishing and maintaining governing lines and benchmarks to prime horizontal and vertical controls to which construction may be referred.
- (b) Inspecting the construction contractor's workmanship, materials, and equipment and report on their conformance or nonconformance with the approved drawings and specifications.
- (c) Making or procuring such field or laboratory tests as are necessary to assure that construction materials and practices are in accordance with the approved drawings and specifications.
- (d) Marking up field copies of the design drawings and specifications to show the as-built condition for submittal to the designer for incorporation into the as-built record drawings.
- (e) Providing input to construction progress reports as required.
- (f) Verifying that planned quality control measures are implemented and evaluate the results of those measures to ensure that the work is being completed in accordance with the approved plans and specifications.

Although these services may seem similar to conventional engineering, design, and inspection, there are several important differences that distinguish cleanup design from engineering design on other projects. These differences need to be underscored when estimating cost and schedule requirements. Major factors to be considered by the estimator include:

- o The regulatory process requires rigorous examination of design alternatives prior to the start of cleanup design. This occurs during RI/FS under CERCLA to support a Record of Decision (ROD) or during CMS under RCRA support issuance of a permit. Cleanup design executes a design based on the method identified in the ROD or permit. This often narrows the scope of preliminary design and reduces the cost and schedule requirements. The estimator needs to assess the extent to which design development is required or allowed in cleanup design. In some cases, the ROD or permit will be very specific as in the case of a disposal facility where all features, such as liner systems, as well as configuration, are fixed. In other cases, such as when treatment options like incineration are recommended, considerable design effort may be required.
- o Requirements for engineering during construction including construction observation, design of temporary facilities, quality control, testing, and documentation will often be higher than for conventional construction. This results from the need to conduct construction activities for environmental projects in compliance with rigid regulations governing health and safety, quality assurance, and other project requirements.

4.3.2 Guidelines for Cleanup Estimates

Cleanups are composed of tasks required to prevent or mitigate the migration of hazardous, radioactive or mixed wastes into the environment. More specifically, cleanups include all combinations of engineering, procurement, fabrication, installation, assembly, erection, excavation and disposal required to implement a remedy at a site.

Cleanups exclude the cost of ongoing operations that occur after the completion of a cleanup, such as monitoring, maintenance, and performance evaluations. For environmental cleanups, the division between the cleanup stage 1 operations, and post-closure phases is often unclear. In certain cases, for example a ground water cleanup, the pumping and treating of the groundwater is an operations activity even though it substantially contributes to the

effectiveness of the cleanup. Other projects may have very little operations and maintenance, especially if a permanent remedy is implemented at the site. Table 4.1 further delineates the differences between cleanup actions and operations.

Distinctions Between Cleanup and Operations and Maintenance (O&M)*	
CLEANUP	OPERATIONS
<ul style="list-style-type: none"> o Results in the Mitigation of a Release o Action is of Limited Duration o During Cleanup, the Site is Restored to a Specified Level Generally Based on Contaminant Levels 	<ul style="list-style-type: none"> o Required to Stop or Control Continued Migration after the Cleanup o Requires Long-Term or Indefinite Activities o Activities Required to Maintain the Goals of the Cleanup

* Adapted from: B. Burgher, M. Culpepper, and W. Zieger, *The Cleanups Costing Procedures Manual* EPA/600/8-87/049, October 1987, p. 3-6.

Table 4-1

In terms of work elements, cleanup activities often resemble standard construction jobs. However, there are some differences. One obvious difference is the level of personnel protection and its effects on manpower requirements. Another dissimilarity is the potential for the transportation and disposal/treatment of a large amount of material a significant distance from the waste site. Off-site activities are often costly and difficult to control. Perhaps the biggest difference is the wide variance in the nature of the work. For most containment remedies, most of the work surrounds the movement of contaminated soils and structures. Treatment remedies, however, frequently involve the installation of major systems to treat wastes and more closely mirror on-going construction projects within DOE.

All construction undertaken to respond to environmental regulations, including RCRA, HSWA, CERCLA and SARA, is considered cleanup. While there are some minor distinctions between the implementation of remedies under various regulations, cleanups consist of similar work elements. Most cleanups are organized according to the major tasks associated with the cleanup. For example, a recently completed cleanup included the following major elements of work:

- o Site Preparation (including demolition and disposal of uncontaminated structures; excavation of uncontaminated materials; and installation of wastewater retention basin)
- o Installation of Geochemical/Flow Liner
- o Excavation of Contaminated Soils
- o Installation of Clay Cap

- o Erosion Protection
- o Site Restoration
- o Installation of Monitoring Wells

Since specific tasks will vary by project, a more generic set of work elements has been identified to provide guidance for estimators. These major work elements are described below.²

4.3.2.1 Cleanup Construction

All equipment, labor, and materials required to install a remedy are considered part of cleanup construction. Construction can consist of the following activities:

- o Site Modifications (e.g., installation of containment systems, excavation of contaminated and uncontaminated materials, site preparation for installation of equipment);
- o Demolition of Existing Structures
- o Installation of Equipment (e.g., construction of pumping systems; construction required for installation of treatment systems; installation of testing and monitoring equipment); and
- o Surface Controls (e.g., erosion control, site restoration).

4.3.2.2 Major Equipment/Process Systems

Remedies often call for the installation of major pieces of equipment at a site. Typical equipment includes: treatment systems (e.g., incinerators, air strippers); pumping systems; and monitoring systems. A variety of "off-the-shelf" systems can be purchased for routine cleanup applications. In many cases, however, the equipment will require field fabrication. Direct vendor quotes on major equipment items will greatly facilitate the cost estimating process.

4.3.2.3 Land and Site Development

While the purchase of new land is unlikely for DOE cleanup activities, there may be instances where site access or contamination beyond property lines will result in land acquisition or usage. Site development includes the cost of general site clearing, grading, drainage, and facilities common to the project as a whole (e.g., access roads, fences, signs, etc.).

4.3.2.4 Buildings and Utilities

Temporary or permanent buildings may be required to implement a remedy. Buildings may be needed for support functions, such as laboratories, process control rooms, decontamination facilities, or support buildings. Other structures may be an integral component of the cleanup (e.g., facilities for major equipment). Utilities may or may not be available at the site. Water and sewer lines, electrical transmission and distribution systems, communication systems, alarm systems and other energy sources may be required.

4.3.2.5 Relocation of Affected Population (Where Appropriate)

In some cases, populations affected by the hazardous waste may require compensation for relocation and other damages. Relocation may involve temporary or permanent accommodations, moving allocations, and other related costs.

² Portions of this section have been augmented by material found in: B. Burgher, M. Culpepper, and W. Zieger, *Remedial Action Costing Procedures Manual*, EPA/600/8-87/049, October 1987.

43.2.6 Transportation and Disposal of Waste Materials

When appropriate on-site disposal or treatment is not available for all waste materials generated during the course of implementing the remedy, then these materials must be transported and disposed of off-site. There may be a variety of off-site disposal options depending on the characteristics of the waste.

43.2.7 Indirect Costs

The calculation of indirect costs is based primarily on the type of cleanup contract. For fixed price or lump sum contracts, indirect costs are expenditures for those items that are ancillary to the actual cleanup activities noted above. These items may differ from a standard construction project and therefore may require more attention. Indirect costs on lump sum contracts can include:

- o Non-Specialized Construction Equipment
- o Field Overhead
- o Office Overhead
- o Temporary Facilities
- o Supplies
- o Insurance and Bonds
- o Permits
- o Equipment Startup and Testing
- o Legal Support
- o Citizen Participation Activities
- o Move-In/Move-Out Activities
- o Quality Insurance Documentation
- o Health and Safety Oversight and Training
- o Profit

For cost type contracts, the only item of indirect cost is the fee. All other costs are listed as direct costs.

4.4 Guidelines for Activity and Program Management

When distinguishing between activity management and program management, this handbook assumes a program organization structure with three levels; headquarters, operations office, and installation. The first two levels are self explanatory since they coincide with recognized levels within the DOE organization. The last level, installation, applies to locations below the operations office level, such as those represented by area offices within the Albuquerque operations complex. It should be understood that the organization need not and does not correspond with the Work Breakdown Structure. Program management occurs at the headquarters, operations office, and installation levels. Activity management occurs only at the operations office or installation level where tasks are actually performed.

The recommended definitions of program and activity management for cost estimating purposes are as follows:

Program Management. Those services provided to the DOE on a specific program for planning, organizing, directing, controlling, budgeting, and reporting on the program. Program management will be provided at multiple levels within the EM program including the Headquarters, operations office, and installation. Program management includes program support.

Program Support. Program support covers those activities performed for internal management and technical support of the Program by part time or full time personnel. The following activities are illustrative of services included in this category:

- o Program document control.
- o Development of program plans and auditing of activity level functions for compliance with programmatic quality assurance, health physics, safety, environmental, and related requirements.
- o Design review or technical oversight of activity level functions by including independent technical analysis, constructability review, life cycle cost comparisons, life safety review, health physics review, and code checks.
- o Program level reporting, budgeting, and planning.
- o Purchasing, contracting, and other functions required to obtain the services of outside contractors.

Activity Management. Activity management services are those provided to the ER Program on a specific activity beginning at the start of assessment and continuing through the completion of the cleanup. Activity management includes those services required to plan, organize, direct, control, and report on the activity. The cost of construction management is rolled up into activity management. The following functions are illustrative of services included in activity management:

- o Technical management and liaison with the designers during cleanup design.
- o Coordination, including interface control during design and construction.
- o Maintenance and operation of scheduling, estimating, and activity control systems during design and cleanup.
- o Technical management and coordination; of the construction management staff.
- o Overall management and coordination of the activities of non-dedicated activity support personnel.
- o Technical management of review and approval activities conducted by dedicated management personnel.
- o Coordination of all aspects of the activity.
- o Preparation of activity plans, activity management plans, and quality assurance project plans.

Construction Management. Those activity management services required to manage construction or cleanup activities including review and approval, cleanup bid package review and acceptance of construction test procedures, control of field design change requests, and review and approval of contractor pay requests. The construction manager provides items and services not included in the construction contractor's bid package such as debris removal, temporary facilities, site security, and storage.

All of the above functions, program management, program support, activity management, and construction management, will be charged directly to the Environmental Restoration Program to the extent allowed by DOE policy. When Management and Operating (M&O) contractors are providing program or activity management services, only those services will be charged to EM which are incremental and not covered under the operating contract as required by DOE Order 2200.6.

Activity support services, which consist of activities performed by the M&O contractor for internal management and technical support of activities or programs but are within the scope of the operating contract, are not chargeable to the program. Examples of activity support services include establishment and maintenance of site programs for health, safety, quality assurance, legal affairs, training, and security.

The subject of program and project management cost estimating has been addressed by the DOE on several occasions in the last five years, most recently by the DOE Committee for Cost Methods Development chaired

by Mr. B. R. Scarlett, Director of Independent Cost Estimating. DOE guidance identifies several common elements applicable to ER that form the basis of allowance costs for project and program management:

1. Construction management cost is rolled up into project management cost.
2. Project management functions should be provided by full time personnel to the greatest extent possible. This does not preclude the use of a matrix organization; however, DOE policy clearly prefers the use of full-time personnel assigned to the project wherever possible.

One element of existing policy and guidance documents for construction projects that is not applicable to estimates prepared for the ER program is the type of funding. Many types of funding are available for potential application on construction projects including line item, GPP, and expenses. However, the ER Program will use only one type of funding. Therefore, this handbook recognizes two types of expenses: allowable and unallowable with allowable expenses to be directly charged to the program.

4.5 Overlaps

It is recognized that there is some overlap of the scopes of services among engineering during construction, construction management, and project management. These should be addressed specifically in the appropriate controlling documents such as the work breakdown structure element definition and contract statement of work, and summarized in the activity plan. Costs are to be charged to activities in accordance with the work breakdown structure element definition.

Construction management and project management are not part of cleanup design and must be estimated and managed separately. The use of consistent format for these estimates will promote accurate budgeting in the early stages and improve the activity management process once work is underway. The cleanup designer shall be instructed in the contract documents to submit cost proposals in a format consistent with the government estimate to facilitate review and expedite negotiations. Agreement on a detailed scope of work and corresponding cost of services will greatly reduce change orders resulting from ambiguous scope definition and, at the same time, provide a firm baseline from which to negotiate changes that do occur during the period of performance.

CHAPTER 5

5.0 WORK BREAKDOWN STRUCTURE

The Environmental Restoration Program Summary Work Breakdown Structure (WBS) provides a framework for all program management functions for a project. The WBS will integrate budget, scope, and schedule through a program oriented hierarchy that begins at the highest level with the DOE Environmental Restoration program and progressively subdivides the work into smaller increments down to the activity level. Further subdivision below the task level will be left to the individual sites to accomplish based on site specific needs. The entire WBS is indicated graphically in Figure 5-1. A WBS Index and WBS Element Definitions are also provided in Figure 5-2.

5.1 Field Office and Installation Definitions

The first level of the WBS is the On-Site Remediation program. The second level consists of the field offices and the DOE ER Headquarters office. The third level comprises the various installation offices or other sites (Facilities & Sites) within an operations office and also includes the field program management functions of a field office. The level three WBS categories of Program Management (field) and Facilities/Sites are the same for each field office.

ENVIRONMENTAL RESTORATION PROGRAM

- 1. On-Site Remediation Program
 - 1.1 Albuquerque
 - 1.1.1 Installation Remediation - Kansas City
 - 1.1.2 Installation Remediation - Los Alamos National Laboratory
 - 1.1.3 Installation Remediation - Mound
 - 1.1.4 Installation Remediation - Pantex
 - 1.1.5 Installation Remediation - Pinellas
 - 1.1.6 Installation Remediation - Sandia National Laboratory-Albuquerque
 - 1.1.7 Installation Remediation - Sandia National Laboratory-Livermore
 - 1.1.X Installation Remediation - Etc.
 - 1.1.X.2 RCRA
 - 1.1.X.2.1 RCRA Project 1
 - 1.1.X.2.1.1 Assessment
 - 1.1.X.2.1.2 Cleanup (Remediation)
 - 1.2 Chicago
 - 1.3 Idaho
 - 1.4 Nevada
 - 1.5 Oak Ridge
 - 1.5.1 Installation Remediation - Feed Materials Production Center
 - 1.5.2 Installation Remediation - Oak Ridge National Laboratory
 - 1.5.3 Installation Remediation - Y-12 Plant
 - 1.5.4 Installation Remediation - Oak Ridge Gaseous Diffusion Plant
 - 1.5.5 Installation Remediation - Paducah Gaseous Diffusion Plant
 - 1.5.6 Installation Remediation - Portsmouth Gaseous Diffusion Plant
 - 1.5.X Installation Remediation - Etc.
 - 1.6 Richland
 - 1.7 Rocky Flats

- 1.8 San Francisco
- 1.9 Savannah River
- 1.10 Headquarters*
- 1.X.X Etc.

*Lower level WBS Elements not addressed by the EM-CAT Team.

The remaining fields of the WBS below level three Facilities/Sites are the same for each area office. The full WBS can be obtained by replacing the "X.X" at level three of the WBS with the appropriate installation code from the above list (i.e., 1.1.4 for Albuquerque - Pantex).

5.2 Regulatory Summary

Four categories of work are recognized at level four of the WBS and these correspond with the Budget and Reporting (B&R) codes established for the ER program as follows:

<u>Category</u>	<u>B&R Code</u>	<u>WBS Code</u>
CERCLA	EW-20-10-10	1
RCRA	EW-20-10-20	2
RCRA/CERCLA	EW-20-10-30	3
Program Management	EW-20-10-55	4

The WBS identification for each regulatory summary category may be shown at level four by indicating the appropriate code from the above list.

5.3 Projects and Activities

Level 5 of the WBS is the project level. A project is a discrete collection of activities within the scope of the ER Program having a defined scope and a definite beginning and end. A project can include a site or group of release sites for which assessment or remediation are planned, a facility or structure, or a discrete group of activities such as those associated with installation level management of the ER Program. Projects shall be numbered consecutively.

Much of the work performed under the ER program will be for the assessment and cleanup of potential release sites. It is important to realize that not all assessment activities will result in cleanup. It is possible that no contamination will be found and no cleanup will be required. However, if cleanup is required, both an assessment and a cleanup activities will be required. The ER program will also include activities other than cleanup such as:

1. Program management at the installation level.
2. Installation level NEPA activities such as environmental assessments.
3. Community relations and other public involvement activities at the installation level.
4. Environmental monitoring.
5. Exploratory or analytical equipment and facilities required to conduct restoration efforts under a number of different activities.

Fig. 5.1. Program Summary Work Breakdown Structure.

These normally will be included as elements of Program Management at level four of the WBS; however, application may vary between sites and project size.

Level six of the WBS will be the activity level and correspond with the activity data sheets of the Five Year Plan. Assessment tasks will be indicated with a 1 in WBS field six and remediation activities with a 2. Activities that are not related to assessment or cleanup shall be numbered 3. (This recommendation holds if we want to include non-assessment, non-remediation activities in the WBS as projects under the applicable regulatory regime. An alternate approach would be to place these projects under Program Management.)

The following Table illustrates the hierarchical application of the WBS codes discussed in the section:

1.X.X.1.Z.1 Subcategory - CERCLA Assessment

Preliminary Assessment/Site Inspection

Those activities associated with the identification of candidate sites for cleanup action.

Remedial Investigation/Feasibility Study

- A. Data collection, analysis and risk assessment required to characterize a site.
- B. Identification of technologies and processes appropriate in the neutralization and removal of the site hazard(s).
- C. Analysis of environmental consequences and preparation of Environmental Impact Statement if required.
- D. Development of the Community Relations Plan.
- E. Issuance of the Work Plan, QA/QC Plan, Sampling and Analysis Plan and the Health and Safety Plan.
- F. Development of alternative cleanup actions and selection of most promising.
- G. Performance of bench/pilot test and/or additional site characterization studies.

1.X.X.1.Z.2 Subcategory - CERCLA Cleanup

Cleanup Design

Those engineering activities associated with the preparation of design criteria, the development and documentation of engineering calculations and the issuance of specifications and drawings which define the cleanup action. This may also include the preparation of operating and/or maintenance manuals required for Post Cleanup Action Operation and Maintenance.

Cleanup Action

Those construction/implementation activities performed in accordance with the Cleanup Design to neutralize the hazard(s) associated with the site, including the operation and maintenance of any waste processing, handling, disposal and monitoring facilities required to complete cleanup. Note that where long-term monitoring or treatment processes are required, EM funds will not be provided.

1.XX.2.2.1 Subcategory - RCRA Assessment

Facility Assessment

Those activities associated with initial assessment of the problem and identification of interim measures.

Facility Investigation

- A. Determination of the nature and the extent of contamination and implementation of interim measures.**
- B. Pre-investigation of corrective measures technologies.**
- C. Preparation of the Facility Investigation Work Plans, such as the Project Management Plan, Data Collection Plan, Quality Assurance Plan, Data Management Plan, etc.**
- D. Investigation of the facility including environmental setting, source and contaminate characterization, and potential receptor identification.**
- E. Analysis of data and investigation of applicable protection standards.**
- F. Performance of laboratory and bench-scale operations.**
- G. Preparation of final report.**

Corrective Measures Study

- A. Preparation of the program Management Plan and Community Relations Plan.**
- B. Identification and development of the corrective measure alternatives.**
- C. Evaluation of the corrective measure alternative or alternatives.**
- D. Justification and recommendation of the corrective measure or measures.**
- E. Preparation and issuance of reports.**

1.XX.2.2.2 Subcategory - RCRA Cleanup

Corrective Measures Design

- A. Preparation of Design Plans and Specifications, Operation and Maintenance Plans and Health and Safety Plan.**
- B. Preparation of cost estimate.**
- C. Finalization of detailed design including preparation of drawings, specifications, etc.**

Corrective Measures

- A. All construction and construction related activities including inspection, quality assurance, personnel qualifications, sampling requirements and documentation.**
- B. Preparation of reports.**

1.XX.3 RCRA/CERCLA

Subcategories are to be developed on a site specific basis.

1.XX.4 Program Management

Lower level WBS elements not addressed by the EM-CAT team.

5.4 Flexibility

The ER program must be flexible if it is to be effective in meeting many broad and challenging requirements. This flexibility must be recognized by the Work Breakdown Structure. Examples of flexibility include:

- 1. Site specific circumstances may dictate the need to establish subcategories other than those shown in this Handbook.**

2. Environmental regulations may change and the scope of cleanup tasks may have to be modified to achieve regulatory compliance.
3. The size or importance of a particular task may require increased management attention and a task or sub-category may be established at level five or six of the WBS to provide this visibility.

The most important concept is that traceability is of paramount importance and, while flexibility is certainly needed, adequate documentation should be maintained at all times. Modification to the WBS should be documented, at a minimum with an updated WBS index, a number based on an extension of the established numbering system and an element description.

U.S. DEPARTMENT OF ENERGY
WORK BREAKDOWN STRUCTURE DICTIONARY
PART I - INDEX

F1332.10

4)

FORM APPROVED
OMB NO. 1901-1400

1. PROJECT TITLE/PARTICIPANT											2. DATE		3. IDENTIFICATION NUMBER	
Environmental Restoration/Department of Energy (DOE)											3/20/90			
LINE NO.	5. WBS ELEMENTS										6. PARTICIPANT WBS ELEMENT CODE	7. BUDGET AND REPORTING NO.	8. PHASE	9. OTHER
	INDENTURE LEVEL								TITLE					
	1	2	3	4	5	6	-	-						
	X									On-Site Remediation Program	1.0			
		X								Albuquerque	1.1			
			X							Kansas City Plant	1.1.1			
			X							Los Alamos Scientific Laboratory	1.1.2			
			X							Mound	1.1.3			
			X							Pantex	1.1.4			
			X							Pinellas	1.1.5			
			X							Sandia Nat'l. Lab. Albuquerque	1.1.6			
			X							Sandia Nat'l. Lab. Livermore	1.1.7			
			X							Etc.	1.1.X			
		X								Chicago	1.2			
			X							Facilities & Sites	1.2.1			
			X							Program Management - Field	1.2.2			
		X								Idaho	1.3			
			X							Facilities & Sites	1.3.1			
			X							Program Management - Field	1.3.2			
		X								Nevada	1.4			
			X							Facilities & Sites	1.4.1			
			X							Program Management - Field	1.4.2			
		X								Oak Ridge	1.5			
			X							Feed Materials Production Ctr.	1.5.1			
			X							Oak Ridge National Laboratory	1.5.2			
			X							Y-12 Plant	1.5.3			
			X							Oak Ridge Gaseous Diffusion Plant	1.5.4			
			X							Paducah Gaseous Diffusion Plant	1.5.5			
			X							Portsmouth Gaseous Diffusion Plant	1.5.6			
			X							Etc.	1.5.X			
		X								Richland	1.6			
			X							Facilities & Sites	1.6.1			
			X							Program Management - Field	1.6.2			
		X								Rocky Flats	1.7			
			X							Facilities & Sites	1.7.1			
			X							Program Management - Field	1.7.2			
		X								San Francisco	1.8			
			X							Facilities & Sites	1.8.1			
			X							Program Management - Field	1.8.2			
		X								Savannah River	1.9			
			X							Facilities & Sites	1.9.1			
			X							Program Management - Field	1.9.2			
		X								Headquarters	1.10			
			X							Etc.	1.10.X			
				X						CERCLA	1.X.X.1			
					X					Project Z	1.X.X.1.Z			
						X				Assessment	1.X.X.1.Z.1			
						X				Cleanup	1.X.X.1.Z.2			

Figure 5-2^a

WORK BREAKDOWN STRUCTURE DICTIONARY PART I - INDEX

PURPOSE

The work breakdown structure index lists the preliminary work breakdown structure elements extended to the lowest level required. Complete only applicable blocks. Specific project requirements may be added as needed.

INSTRUCTIONS

Item 1. Enter project title and name of participant.

Item 2. Enter date of preparation.

Item 3. Enter applicable contractual agreement number.

Item 4. Enter sequential numbers to identify each entry.

Item 5. Enter the work breakdown structure element title and an "X" to reflect the level (e.g., level 1 is the contract); level 2, 3, etc., are successively lower indentures of the contract work breakdown structure). Enter an asterisk (*) before the title of each element to be reported. Enter a parenthetic (s/c) following each subcontract element title.

Item 6. Enter the code devised by the participant for internal identification of the work breakdown structure element.

Item 7. Enter the appropriate Budget and Reporting (B&R) number.

Item 8. Enter the appropriate designator from the table below to identify the project phase. (See DOE 5700.3B, MAJOR SYSTEM ACQUISITION PROCEDURES, Attachment 3, for reference):

- 1 = Basic Research, Applied Research, or Technology or Exploratory Development
- 2 = Advanced Development
- 3 = Engineering Development
- 4 = Demonstration
- 5 = Operation/Production

Since construction may take place under all of the above phases a second code, "C", may be necessary (e.g., a construction project occurring during the "engineering development" phase would be designated "3C").

Item 9. Add columns as required to cross-reference the work breakdown structure element to other pertinent documents. For example, columns may be added for System Design Description Number, Configuration Item Number, Statement of Work Number, etc., and the applicable reference entered.

U.S. DEPARTMENT OF ENERGY
WORK BREAKDOWN STRUCTURE DICTIONARY
PART I - INDEX

F1332.10
34)

FORM APPROVED
OMB NO. 1901-1400

PROJECT TITLE/PARTICIPANT Environmental Restoration/Department of Energy (DOE)										2. DATE 3/20/90		3. IDENTIFICATION NUMBER	
NE O.	5. WBS ELEMENTS								6. PARTICIPANT WBS ELEMENT CODE	7. BUDGET AND REPORTING NO.	8. PHASE	9. OTHER	
	INDENTURE LEVEL												
	1	2	3	4	5	6	-	-					
6.				X					RCRA Project Z Assessment Cleanup 1XX.2 1XX.2.Z 1XX.2.Z.1 1XX.2.Z.2				
7.					X								
8.						X							
9.						X							
<p>*Lower level WBS elements not addressed by the EM-CAT Team.</p> <p>¹ Replace "X" with appropriate level 3 code.</p> <p>² Replace "X.X" with appropriate level 2 and 3 code from above.</p> <p>³ Replace "Y" with appropriate level 4 Operable Unit ID.</p> <p>⁴ Replace "Z" with appropriate level 5 Task ID.</p> <p>⁵ See write-up (Section 5.2)</p>													

Figure 5-2^b
5-8

Sep. 90
Rev. 0

WORK BREAKDOWN STRUCTURE DICTIONARY PART I - INDEX

PURPOSE

The work breakdown structure index lists the preliminary work breakdown structure elements extended to the lowest level required. Complete only applicable blocks. Specific project requirements may be added as needed.

INSTRUCTIONS

Item 1. Enter project title and name of participant.

Item 2. Enter date of preparation.

Item 3. Enter applicable contractual agreement number.

Item 4. Enter sequential numbers to identify each entry.

Item 5. Enter the work breakdown structure element title and an "X" to reflect the level (e.g., level 1 is the contract; level 2, 3, etc., are successively lower indentures of the contract work breakdown structure). Enter an asterisk (*) before the title of each element to be reported. Enter a parenthesis (s/c) following each subcontract element title.

Item 6. Enter the code devised by the participant for internal identification of the work breakdown structure element.

Item 7. Enter the appropriate Budget and Reporting (B&R) number.

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- 1 = Basic Research, Applied Research, or Technology or Exploratory Development
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- 3 = Engineering Development
- 4 = Demonstration
- 5 = Operation/Production

Since construction may take place under all of the above phases a second code, "C", may be necessary (e.g., a construction project occurring during the "engineering development" phase would be designated "3C").

Item 9. Add columns as required to cross-reference the work breakdown structure element to other pertinent documents. For example, columns may be added for System Design Description Number, Configuration Item Number, Statement of Work Number, etc., and the applicable reference entered.

**U.S. DEPARTMENT OF ENERGY
WORK BREAKDOWN STRUCTURE DICTIONARY
PART II – ELEMENT DEFINITION**

FE P1332.11
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FORM APPROVED
OMB NO. 1901-1400

1. PROJECT TITLE/PARTICIPANT Environmental Restoration/ DOE Operations Office		2. DATE 3/20/90	3. IDENTIFICATION NUMBER
4. WBS ELEMENT CODE 1.X.X.1.Z.1		5. WBS ELEMENT TITLE CERCLA Assessment Activity	
6. INDEX LINE NO. 44	7. REVISION NO. AND AUTHORIZATION		8. DATE
9. APPROVED CHANGES			
10. SYSTEM DESIGN DESCRIPTION		11. BUDGET AND REPORTING NUMBER	
12. ELEMENT TASK DESCRIPTION			

Element of Cost:

All cost associated with the accomplishment of this sub-category shall be charged with this sub-category. Cost shall include all direct and indirect labor and materials, travel, procurement, etc., incurred by DOE and DOE contractors.

Technical Content:

To be provided by participant performing activities associated with the contract WBS elements.

Functional Activities:

Consists of those activities associated with:

- A. Data collection, analysis and risk assessment required to characterize a site.
- B. Identification of technologies and processes appropriate in the neutralization and removal of the site hazard(s).
- C. Analysis of environmental consequences and preparation of Environmental Impact Statement if required.
- D. Development of the Community Relations Plan.
- E. Issuance of the Work Plan, QA/QC Plan, Sampling and Analysis Plan and the Health and Safety Plan.
- F. Development of alternative remedial actions and selection of most promising.
- G. Performance of bench/pilot tests and/or additional site characterization studies.

**U.S. DEPARTMENT OF ENERGY
WORK BREAKDOWN STRUCTURE DICTIONARY
PART II – ELEMENT DEFINITION**

DOE F1332.11
(11-84)

FORM APPROVED
OMB NO. 1901-1406

1. PROJECT TITLE/PARTICIPANT Environmental Restoration/ DOE Operations Office		2. DATE 3/20/90	3. IDENTIFICATION NUM
4. WBS ELEMENT CODE 1.X.X.1.Z.2		5. WBS ELEMENT TITLE CERCLA Cleanup	
6. INDEX LINE NO. 45	7. REVISION NO. AND AUTHORIZATION		8. DATE
9. APPROVED CHANGES			
10. SYSTEM DESIGN DESCRIPTION		11. BUDGET AND REPORTING NUMBER	
12. ELEMENT TASK DESCRIPTION			
<p>Element of Cost:</p> <p>All cost associated with the accomplishment of this sub-category shall be charged with this sub-category. Cost shall include all direct and indirect labor and materials, travel, procurement, etc., incurred by DOE and DOE contractors.</p> <p>Technical Content:</p> <p>To be provided by participant performing activities associated with the contract WBS elements.</p> <p>Functional Activities:</p> <p>Consists of those activities associated with:</p> <ul style="list-style-type: none"> A. Planning and scoping. B. Preparation of design criteria. C. Preparation of cost estimates. D. Finalization of detailed design including preparation of drawings, specifications, etc. E. Preparation of operating and/or maintenance manuals. <p>Consists of those construction/implementation activities performed in accordance with the Remedial Design to neutralize the hazard(s) associated with the site, including:</p> <ul style="list-style-type: none"> A. All construction and construction related activities including inspection, quality assurance, personnel qualifications, sampling and documentation. B. The operation and maintenance of any waste processing, handling, disposal and monitoring facilities required to complete remediation. C. Preparation of reports. 			

U.S. DEPARTMENT OF ENERGY
WORK BREAKDOWN STRUCTURE DICTIONARY
PART II – ELEMENT DEFINITION

EF 1332.11
 (84)

FORM APPROVED
 OMB NO. 1901-1400

1. PROJECT TITLE/PARTICIPANT Environmental Restoration/ DOE Operations Office		2. DATE 3/20/90	3. IDENTIFICATION NUMBER
4. WBS ELEMENT CODE 1.X.X.2.Z.1		5. WBS ELEMENT TITLE RCRA Assessment	
6. INDEX LINE NO. 48	7. REVISION NO. AND AUTHORIZATION		8. DATE
9. APPROVED CHANGES			
10. SYSTEM DESIGN DESCRIPTION		11. BUDGET AND REPORTING NUMBER	
12. ELEMENT TASK DESCRIPTION			

Element of Cost:

All cost associated with the accomplishment of this sub-category shall be charged with this sub-category. Cost shall include all direct and indirect labor and materials, travel, procurement, etc., incurred by DOE and DOE contractors.

Technical Content:

To be provided by participant performing activities associated with the contract WBS elements.

Functional Activities:

Consists of those activities associated with initial assessment of the site to identify potential sources of release and identification of interim measures where necessary, including:

- A. Planning and scoping.
- B. Review of historical data.
- C. Interviews with personnel familiar with the site.
- D. Site visit.
- E. Assessment of data adequacy.
- F. Sampling and analysis, if required.
- G. Regulatory review.
- H. Peer review.
- I. Agency contacts and meetings.
- J. Issuance of final report.
- K. Interim remedial actions.

**U.S. DEPARTMENT OF ENERGY
WORK BREAKDOWN STRUCTURE DICTIONARY
PART II - ELEMENT DEFINITION**

DOE F1332.11
(11-84)

FORM APPROVED
OMB NO. 1901-1400

1. PROJECT TITLE/PARTICIPANT Environmental Restoration/ DOE Operations Office		2. DATE 3/20/90	3. IDENTIFICATION NUMBER
4. WBS ELEMENT CODE 1.X.X.2.Z.1		5. WBS ELEMENT TITLE RCRA Assessment (Continued)	
6. INDEX LINE NO. 48	7. REVISION NO. AND AUTHORIZATION		8. DATE
9. APPROVED CHANGES			
10. SYSTEM DESIGN DESCRIPTION		11. BUDGET AND REPORTING NUMBER	
12. ELEMENT TASK DESCRIPTION <p>Consists of those activities associated with:</p> <ul style="list-style-type: none"> A. Preparation of the Program Management Plan and Community Relations Plan. B. Identification and development of the corrective measure alternatives. C. Evaluation of the corrective measure alternative or alternatives. D. Justification and recommendation of the corrective measure or measures. E. Preparation and issuance of reports. <p>Consists of those activities associated with:</p> <ul style="list-style-type: none"> A. Determination of the nature and the extent of contamination and implementation of interim measures. B. Pre-investigation of corrective measures technologies. C. Preparation of the Facility Investigation Work Plans, such as the Project Management Plan, Data Collection Plan, Quality Assurance Plan, Data Management Plan, etc. D. Investigation of the facility including environmental setting, source and contaminant characterization, and potential receptor identification. E. Analysis of data and investigation of applicable protection standards. F. Performance of laboratory and bench-scale operations. G. Preparation of final report. 			

**U.S. DEPARTMENT OF ENERGY
WORK BREAKDOWN STRUCTURE DICTIONARY
PART II – ELEMENT DEFINITION**

FE P1332.11
941

FORM APPROVED
OMB NO 1901-1400

1. PROJECT TITLE/PARTICIPANT Environmental Restoration/ DOE Operations Office		2. DATE 3/20/90	3. IDENTIFICATION NUMBER
4. WBS ELEMENT CODE 1.X.X.2.Z.2		5. WBS ELEMENT TITLE RCRA Cleanup	
6. INDEX LINE NO. 49	7. REVISION NO. AND AUTHORIZATION		8. DATE
9. APPROVED CHANGES			
10. SYSTEM DESIGN DESCRIPTION		11. BUDGET AND REPORTING NUMBER	

12. ELEMENT TASK DESCRIPTION

Element of Cost:

All cost associated with the accomplishment of this sub-category shall be charged with this sub-category. Cost shall include all direct and indirect labor and materials, travel, procurement, etc., incurred by DOE and DOE contractors.

Technical Content:

To be provided by participant performing activities associated with the contract WBS elements.

Functional Activities:

Consists of those activities associated with:

- A. Planning and scoping.
- B. Preparation of design criteria.
- C. Preparation of cost estimates.
- D. Finalization of detailed design including preparation of drawings, specifications, etc.
- E. Preparation of operating and/or maintenance manuals.

Consists of those activities associated with:

- A. All construction and construction related activities including inspection, quality assurance, personnel qualifications, sampling requirements and documentation.
- B. Preparation of reports.

CHAPTER 6

6.0 CONTINGENCY

6.1 Introduction

Environmental Restoration (ER) projects pose unique difficulties and challenges for the estimator. They are characterized by greater uncertainty than typical construction projects since contaminate types, amount of contamination, and the remedial technology are often not known until a detailed assessment has been completed. As a result, traditional engineering and construction estimating methodologies have failed to provide reasonably accurate estimates for ER projects. The purpose of this section is to provide guidance and a standard approach to the DOE community regarding contingency estimating practices for ER projects.

This section will address the following areas:

- o The cost estimating record for ER projects
- o Definition of contingency
- o Factors affecting a contingency
- o Generic guidelines for developing a contingency
- o Detailed guidance for developing contingency estimates for specific project stages

It should be noted that DOE has invested considerable effort and training into contingency analysis. The contingency techniques at each site are derivatives of the report of the Committee for Cost Method Development, Volumes 1-6. The contingency guides outlined later in this section were built from that report and were supplemented with additional information.³

6.2 Cost Growth in Environmental Restoration Projects

While many cleanup programs are just underway, there is enough collective experience across the country to assess the accuracy of cost estimates for this class of projects. Figure 6-1 graphically depicts the accuracy of cost estimates for 40 projects completed over the past decade. The vertical axis measures the percent deviation between actual project cost and estimated cost for the design and construction stages of a remediation⁴. The horizontal axis indicates the stage at which the estimate was made using CERCLA/SARA terminology. In theory, the ratio of the actual cost to the estimated cost should average zero with a narrowing band of variability around this ratio towards the completion of the project (cross-hatched area of chart). In reality, however, there is a problem with both estimate accuracy and variability. The figure shows a consistent problem with underestimation, especially at early project stages. In addition, there is a wide variance in the accuracy of the estimates. At early project stages, estimates can be underestimated by as much as 243 percent and overestimated by almost 53 percent.⁵

³ IPA, Inc. is in the process of developing the *HAZRISK* models for estimating contingencies for both the assessment and cleanup phases of an ER project. They are expected to be available in the third quarter of 1990.

⁴ All costs were adjusted to constant 1989 U.S. dollars. All contingencies were removed from the original cost estimates. Where possible, changes in scope beyond original project objectives were not included in the analysis.

⁵ Schroeder, B, and Shangraw, R.F., "Parametric Tools for Understanding Cost Growth in Hazardous Waste Cleanup Projects," IPA, Inc., January, 1989.

6.3 Definition of Contingency

Contingency in cost estimates represents an allowance for elements within the project scope that are not included in the detailed estimate. "It is a cost element of an estimate to cover a statistical probability of the occurrence of unforeseeable elements of cost within the defined project scope due to a combination of uncertainties, intangibles and unforeseen/highly unlikely occurrences of future events, based on management decision to assume certain risks (for the occurrence of those events)."⁶

The amount of a contingency is based on a formal professional assessment of project specific factors including design completeness, method of accomplishment, design complexity, construction conditions, and maturity of technology. As a project progresses in development from conceptual through definitive design, uncertainties related to design diminish because a greater fraction of the Total Estimated Cost (TEC) is incorporated into the known, or detailed, estimate.⁷ However, even when fixed-price contracts are secured for items, a small contingency must be maintained to accommodate construction unknowns such as contractor claims for changed conditions within the scope of a particular contract.

The basis of the contingency used in the estimate should be fully documented. This will reduce the possibility of the contingency being used inappropriately. A contingency should not be used as a "catch-all stop fund" to cover cost overruns that were not included in the basis of the contingency evaluation.⁸ A contingency is not intended to include the following factors especially if they can be estimated at the time of the estimate:

- o Changes in Scope Beyond the Original Project Objectives
- o Inaccurate Projections of Inflation
- o Unanticipated Regulatory Standards
- o Other External Factors (i.e., bad weather, strikes, labor shortages, etc.)
- o Overhead, profit, fee.

Scope changes are defined differently and often used as a "catch-all" term to explain away all cost growth. For our purposes, scope changes are defined as discretionary changes to the design and construction and are external to the accuracy of the estimate. A contingency is not intended to cover cost increases due to previously unrecognized design requirements.⁹ The regulations for ER projects will undoubtedly change with time, which means a higher probability of changing scope than for a standard project. The current understanding for contingency is to cover only the scope of work as it is presently conceived. In addition, changes in the regulations must be accounted for by a change in job scope and a new estimate. Changes in scope, caused by regulation changes or otherwise, are not included in project contingency.

6.4 Factors Affecting a Contingency

The following factors affect the reliability of an estimate and need to be considered when estimating a contingency:

⁶Zaheer, S.H., "Contingency and Capital Estimates," *American Association of Cost Engineer's Notebook*, Morgantown, WV, 1988, p.1-13.

⁷Total Estimated Costs (TEC) of a project is defined as the gross cost of the project including the cost of assessment, investigation, design, cleanup activities, project management, and economic escalation and contingency. This definition is in compliance with the intent of U.S. DOE Order 4700.1 but varies somewhat due to the unique features of restoration projects.

⁸Zaheer, p. 13.

⁹Morrow, E, et al, *Understanding Cost growth and Performance Shortfalls in Pioneer Process Plants*, RAND/R-2569-DOE, Rand Corporation, Santa Monica, CA, September, 1981.

ESTIMATION ACCURACY FOR REMEDIAL ACTIONS

Figure 6-1

Project Definition or Completeness (Assessment, Investigation, Design)-- The degree of project definition is the most important factor affecting an estimate's accuracy. As a project progresses, more detailed information will be made available to the estimator allowing for a reduction in uncertainty. This factor is the major reason for the variance shown in Figures 6-2 and 6-3 for contingency ranges.

The Role of Technology -- The past decade has witnessed the multiplication in the number of new treatment technologies employed at ER sites. The expected growth in the ER industry will mean the development and use of even more technologies. However, the long time span projected for many ER tasks may lead estimators to adjust cost estimates downward by a Technology-Productivity-Improvement (TPI) factor. The use of a TPI factor is justified due to a learning curve effect gained with technology. A discussion of the TPI can be found in Appendix A at the end of this chapter.

However, past experience in ER and other types of projects has demonstrated that the learning curve is not present in projects implementing new technology on a continual basis. Previous studies of the process plant industry have shown that the use of innovative and first-of-a-kind technology leads to cost growth.¹⁰ Further evidence of this effect is provided by EPA's experience with new technology at ER sites. Studies at EPA Superfund sites have shown that the use of unproven technology is one of the primary causes of cost growth.¹¹ EPA has not seen cost reductions due to a learning curve effect over the past ten years of the Superfund program and, as a result, does not use a TPI factor to adjust their estimates. Since this factor can have varying effects, the estimator's good judgement in applying a technology factor is recommended until more evidence is collected for DOE projects.

Complexity of Project -- Contingencies need to take into account the complexity of a project. Project complexity is influenced by the following factors: innovative technology; required reliability; equipment complexity; construction restraints due to continuity of operation; security; contamination and classes of contaminants; environment (weather, terrain, location); scheduling; and waste management permits and reviews.

Price and Market Conditions -- Market condition considerations (force availability and liability insurance expense) are an addition or a subtraction from the project cost that can be accounted for in contingency. Obviously, the certainty of the estimate prices will have a major impact. The closer to a firm quoted unit price for remedial/corrective work, and the definitiveness of the number of units, the lower the contingency.

Public Acceptance--Public acceptance would be considered as a possible cost item. Each site has a unique local population which may or may not approve of the operation and its ER effort. The long-term movement of any radical opinion, from either positive or negative, is to neutral. Some climates, however, are neutral and will remain neutral.

The systematic review of these factors when setting contingencies will help account for uncertainty present in cost estimates. The more information available to the estimator about these factors, and the higher the quality of the information, the more reliable the contingency.

6.5 Generic Guidelines For Developing Contingencies

These guidelines are provided for DOE and Operating Contractor project team members and are based on existing DOE Orders and practices. The application is primarily for CERCLA and RCRA environmental projects. The application of contingency to the various types of cost estimates covers the entire life cycle of a

¹⁰ Merrow, E, et al, *Understanding Cost growth and Performance Shortfalls in Pioneer Process Plants*, RAND/R-2569-DOE, Rand Corporation, Santa Monica, CA, September, 1981.

¹¹ U.S. EPA, Office of Emergency & Remedial Response, "Superfund Cost Escalation Project," prepared by Putnam, Hayes & Bartlett, Inc. Sept. 1987.

project from initial assessment through completion of remediation. The purpose is to provide for a standard approach and to improve the understanding of the contingency analysis process by the project team at the various stages and levels of review.

Detailed guidance is included in this report to improve management and cost estimating practices related to contingency. Considerable latitude is reserved for the estimators and managers; however, justification should be documented when guide ranges for contingency are exceeded. DOE project management policy requires that contingency be clearly identified and included in the Total Estimated Cost. DOE Order 4700.1 states:

"Included in all cost estimates should be a contingency fund comprised of costs which may result from incomplete design, changes due to unforeseen, uncertain, and/or unpredictable conditions (e.g., construction work disturbances due to operations), and expected costs/savings associated with projected market conditions. The amount of the contingency funds will depend on the status of design, procurement, and construction as well as the complexity and uncertainties of the project's component parts. The market condition reserve requirements will depend upon an analysis of anticipated availability of resources to complete the job. Market condition analysis may result in either positive or negative requirement for reserves since, for example, an anticipated shortage of available construction work would indicate possible receipt of lower bids. Care must be exercised during the market condition analysis to consider only those items that are separate from items utilized for computation of inflation rate. Market condition considerations are an addition to or subtraction from the project cost without regard to inflation."¹²

Contingency shall be assigned to elements of the cost at a summary level no higher than WBS Level 3. The cost estimate level at which contingency is assigned should reflect consistency among factors which affect economic risk. In order for accurate contingency calculation, there must be a consistent degree of risk within the cost elements at the contingency assignment level. Of primary importance is the need to have a consistent method of accomplishment (i.e., cost-plus-fixed-fee, firm fixed price) in a cost element at the contingency assignment level to assure that the unique risks associated with these contract types are assessed separately. This is particularly true in the case of special facility equipment items where a substantial range of contracting methods may be employed. In assigning equipment contingencies, cost elements must be separated into WBS elements that group similar technologies of comparable maturity together (i.e., off-the-shelf items, R&D vendor fabrications, items provided by other DOE contractors) for a technical risk assessment.

6.6 Detailed Guidance for Contingency Estimating at Specific Project Stages

The following provides detailed guidelines in estimating a contingency for the assessment and remediation phases of an ER project. These guidelines are to be applied by cost estimators with concurrence of project managers by both the operating contractor and DOE field office. Due to the many projects being planned and carried through various stages of completion, it is recommended that each contractor and field office incorporate these guidelines in their operating procedures. This will assure a consistent and standard approach by the project teams. If extraordinary conditions exist that call for higher contingencies, the rationale and basis shall be documented in the estimate.

A written contingency analysis and estimate shall be performed on all cost estimates and maintained in the estimate documentation file. Estimators may rarely use the ranges provided in this Handbook for estimating small projects. However, a more detailed analysis will be performed on larger projects and will include the basis of the cost estimate and describe the reasons for assigning contingency allowances to the various parts of the estimate. These reasons will be described even when the contingency allowance falls within the brackets described previously.

The contingency to be provided for the current working estimate will be developed on an item-by-item basis. The amount of contingency allowance will be based on the status of the complexity and uncertainties of the

¹²U.S. DOE, "Project Management System," DOE Order 4700.1, March, 1987, p. V-8.

component parts of the estimate. The contingency requirements for each project will be established for each component of the project cost estimate with the total project contingency being a summation of the individually established requirements. Prior to project authorization, the calculated contingency is usually adjusted to achieve a reasonably rounded total estimated project cost.

6.6.1 Guidelines for Assessment Contingency

Cost estimating problems are not limited to the Remediation phase of an ER project. In the RI/FS stage of a CERCLA assessment, for example, costs per operable unit for EPA's Superfund program have shown dramatic real increases during the 1980s. Previous reports have pointed out the variance in the accuracy of assessment estimates and the need for better cost estimating methods.¹³ Unlike the remediation phase, the assessment does not include the physical construction of a remedy. Rather it determines and evaluates the threat presented by the release and evaluates proposed remedies. As a result, the assessment encompasses such items as field investigations, data analysis, screening and evaluation studies and the production of reports.

The factors affecting an assessment contingency come under the same general categories as listed in Section 6.4. However, the considerations affecting the degree of project definition and project complexity differ somewhat:

Project Definition -- The degree of project definition will depend on how well the scope of the assessment is defined. Higher levels of project definition will correspond to increasing levels of work completed on the assessment. Since the assessment is one of the initial stages of the remediation process, there is a high degree of uncertainty regarding the technical characteristics, legal circumstances and level of community concern. As a result, the scope of the assessment often evolves as the project progresses. This uncertainty is so great that sites are often separated into additional operable units and more than one assessment is required. "When this uncertainty is combined with high variability in site size and technical complexity, the scope of assessment activities at a given site are highly variable."¹⁴

Project Complexity -- Considerations which affect the selection of contingency ranges are: number of alternatives screened and evaluated; the level and extent of sampling analysis and data evaluation; the technical and physical characteristics of a site; and the level of planning required.

Figure 6-2 shows the estimate types for the assessment phase of an ER project and their corresponding expected contingency ranges.¹⁵ As the project progresses and becomes better defined, the contingencies become smaller. However, it should be noted that these are only general guidelines based on the level of project definition. Contingency ranges for planning estimates have not been provided given the limited number of documented estimates available at this stage. A higher or lower contingency may be appropriate depending on the level of project complexity, technical innovation, market innovation, and public acceptance (See Section 6.4).

6.6.2 Guidelines for Remedial Design

Based upon detailed analysis of the remaining engineering, contingency factors are applied to the remaining design work. In general, the engineering cost has already been estimated based on general experience of engineering cost on closely related work. Remaining engineering will use the same contingency factor as established in the ROD, permit, or current baseline. This contingency percentage will depend upon the degree of uncertainty associated with the project, particularly the degree of uncertainty in the scheduled completion dates.

¹³U.S. EPA, Office of Program Management, Office of Emergency and Remedial Response, "The RI/FS Cost Study," prepared by Booz-Allen & Hamilton, Inc., August 6, 1988.

¹⁴U.S. EPA, Office of Program Management, Office of Emergency and Remedial Response, "The RI/FS Cost Study," prepared by Booz-Allen & Hamilton, Inc., August 6, 1988.

¹⁵ These ranges are based on actual experience with 50 completed cleanup projects conducted over the past decade as developed by IPA, Inc.

When the job is generally defined by approved documents and time has permitted the development of detailed drawings, engineering costs can be developed using these and other detailed specifications. The contingency is based upon the percent of the remaining work to be performed unless there is some unusual factor to be taken into account, such as a significant change in criteria.

6.6.3. Guidelines for Cleanup Actions

Figure 6-3 shows the estimate types for the cleanup phase and their corresponding expected contingency ranges. The feasibility study estimate has been removed from the chart since the ranges shown for the planning estimates include the expected contingency range for the feasibility study estimate. While the ranges are relatively broad, they reflect the amount of contingency that would have been needed for a set of completed projects¹⁶. The wide variance accounts for differences in project definition when the estimate was generated, project complexity, technical innovation, and other factors. The estimator should review Section 6.4, "Factors Affecting a Contingency," for possible adjustments to these guidelines.

Using the DOE cost code of accounts identity, the guidelines in Table 6-1 are provided for the "detailed" estimate made after the development of remedial drawings and specifications. The guidelines are listed in order of increasing complexity and uncertainty, correlative to recommendations by the Committee for Cost Methods Development for an estimate after detailed design.

Illustration of Contingency Ranges Waste Contaminant and Groundwater Monitoring Detailed Estimate Stage	
Major Task	Contingency Rate
Site Preparation	5% - 10%
Installation of Geochemical/Flow Liner	10% - 20%
Excavation of Contaminated Soils	20% - 40%
Installation of Clay Cap	15% - 20%
Erosion Protection	5% - 10%
Site Restoration	5% - 10%
Installation of Monitoring Wells	10% - 15%

Table 6-1

Considerations that affect the selection in the ranges are: innovative technology; required reliability; equipment complexity; construction restraints due to continuity of operation, security and contamination; environmental (weather, terrain, location); scheduling; and other unique items to the project such as waste management permits and reviews.

¹⁶These numbers have been generated using a database of remedial actions developed for U.S. DOE by Independent Project Analysis, Inc. The database includes both U.S. EPA-led and U.S. DOE-led remedial actions.

Expected Contingency Range for Estimate Types for the Assessment Phase

(Using CERCLA/SARA Terminology)

Figure 6-2

Illustration of Factors Influencing Component Equipment Procurement

- a. For equipment that has not yet been specified and estimated by design, the same contingency as defined in the assessment is applied. The percent contingency will depend upon the complexity and uncertainties involved.
- b. On equipment to be purchased, covered by an approved or official remediation estimate, a contingency of 15 to 20 percent is provided. (In this case, in general, the equipment cost estimate has been estimated based on general experience of equipment cost on the closest related type of equipment.)
- c. On equipment on order under CPFF type of purchase orders, a contingency of 15 percent is provided.
- d. When equipment is on firm fixed-price orders that are undelivered, a contingency of 3 percent to 8 percent of the purchase order price is provided depending upon the type of equipment and its general status of manufacture, including review and approval of shop drawings.

Table 6-2

Prior to the completion of a remedial/corrective measures design estimate, the contingency applied to remaining cleanup work will be no more than that established in the ROD, permit, or current baseline. The percent contingency will depend upon the complexity of the work and the degree of uncertainties involved. When the construction work is defined by definitive design but the cleanup contract has not yet been awarded, a 15 to 20 percent contingency will be provided on the estimated cost. Usually the cost estimate is based on detailed drawings and bills of material. When the cleanup work is to be performed by a CPFF contractor, and the contractor has prepared a detailed estimate of the cleanup cost, and it has been reviewed and approved by DOE, a contingency of 15 percent to about 18 percent is provided on that portion of the cost and commitments remaining to be accrued. On fixed-price cleanup contracts where no significant change orders, modifications, or potential claims are outstanding, a contingency of 3 percent to 8 percent of the uncompleted portion of the work is provided depending upon the type of work involved and the general status of the contract.

Table 6-3 demonstrates the application of contingencies by cost element for both the remedial design and action stages of a project.

EXPECTED CONTINGENCY RANGE FOR ESTIMATE TYPES FOR THE CLEANUP PHASE

(Using CERCLA/SARA Terminology)

Figure 6-3

**Contingency Summary
for Cleanup**

Project Title:

Location:

Element of Cost

Base Cost

Percent

**Contingency
Dollars**

Assessment

100,000

5%

\$ 5,000

Remedial Design

Preliminary Design

50,000

10%

\$ 5,000

Definitive Design

100,000

15%

\$ 15,000

Construction Engineering

100,000

10%

\$ 10,000

Land and Land Rights

0

Remedial Action

Improvements to Land

25,000

20%

\$ 5,000

Buildings

0

Other Structures

500,000

25%

\$125,000

Utilities

50,000

20%

\$ 10,000

Special Process or Facs

75,000

20%

\$ 15,000

Demolition

0

Tunneling

0

Drilling

10,000

30%

\$ 3,000

Waste Removal & Disposal

0

In Situ Treatment

0

Project Management

200,000

10%

\$ 20,000

Standard Equipment

0

\$1,210,000

18%

\$213,000

Total Estimated Cost (TEC) = \$1,210,000 + \$213,000 = \$1,423,000

NOTE: Figures are intended to be illustrative only and are not indicative of a particular project nor are the dollar amounts representative of the relative magnitude of various project costs or of the appropriate contingency.

Table 6-3

APPENDIX A TO CHAPTER 6

APPENDIX A TO CHAPTER 6

Technology-Productivity Improvement

The long time span projected for some EM tasks would allow the advance of technology to improve productivity and reduce costs. Historical information on the general subject indicates evolution in technology with an incremental increase in productivity.* The environmental restoration program, on a nationwide basis, will create a sizable industry, initially drawing from other industries with various backgrounds and experience. Transfer of technology will take place at both the design level and at the contractor level. The application of a general rate of Technology-Productivity Improvement (TPI) should be considered.

The separate line adjustment for TPIs shall be calculated similar to escalation for the forecasted contract periods with a two and one half year delay in implementing the TPI into the next contract. The recommended TPI rate is a negative 2% per year.** An unusual project may indicate a different rate, if so, documentation to support that rate shall be provided. See Figure 6-4 with graph for a project broken into five year contract periods and an equal portion of the task performed each year. Adjust the contract periods and task levels to the specific project schedule you are preparing the estimate for. Document the contract periods assumed and the portions considered for TPI. Normally, the TPI would be applied only to actual field work.

- * Abernathy, William J. and Utterback, James M., "Patterns of Industrial Innovation", Technology Review, Volume 80, Number 7, June/July 1978, edited at the Massachusetts Institute of Technology.
- * Gee, Edwin A. and Tyler, Chaplin, Managing Innovation, John Wiley & Sons, NY, NY 1976.
- * Schnaars, Steven P., Megamistakes, The Free Press, NY, NY. 1989.
- ** Utterback, James M, "Innovation in Industry", Science Vol. 183, No. 4125, 15 Feb. 1974, American Association For The Advancement of Science, Washington, DC.
- ** Sahal, D. Patterns of Technological Innovation, Edison-Wesley, Reading, PA 1981.
- ** Fisher, Harold W., Symposium sponsored by the National Academy of Engineering April 24, 1968. Process of Technological Innovation, National Academy of Sciences, Washington, DC, 1969.

EXAMPLE

TECHNOLOGICAL-PRODUCTIVITY IMPROVEMENT

CALCULATIONS

WORK PERIOD	COST FACTOR	REDUCTION
05-10	5 %	$1/0(X-05\%) = -05/0$
10-15	10 %	$1/0(X-10\%) = -24/0$
15-20	20 %	$1/0(X-20\%) = -44/0$
20-25	41 %	$1/0(X-41\%) = -85/0$
25-30	60 %	$1/0(X-50\%) = -92/0$
		$-242/0 = -24\%$

ASSUMPTIONS FOR EXAMPLE

- EACH CONTRACT PERIOD IS 5 YEARS. GOVERNMENT DOES NOT RECEIVE BENEFIT WITHIN CONTRACT PERIOD.
- 2 1/2 YEAR DELAY IN IMPLEMENTING TECHNOLOGICAL IMPROVEMENTS INTO CONTRACT.
- EQUAL PORTION OF THE TOTAL TASK PERFORMED EACH YEAR.
- TOTAL TASK PERIOD IS 30 YEARS.

REACTION TIME FOR INCLUSION
IN CONTRACT PRICE

Figure 6-4

CHAPTER 7

7.0 ESCALATION

7.1 Guidance for Application of Economic Escalation to Environmental Restoration Projects

This chapter provides guidance in the application of anticipated economic escalation rates to cost estimates. Rates issued by DOE-Headquarters, Independent Cost Estimating (ICE) staff, Table 7-1, shall be applied to labor, construction equipment, construction materials and engineered equipment costs. Until a more specific index is developed, the DP index will be used for EM projects. As noted, local rates which differ from those shown in the table, must be submitted to the ICE staff for approval, prior to their use.

To properly apply escalation rates for a particular project, the following data is required:

- o Escalation rates (including issue date & index) used to prepare the estimate.
- o Current performance schedule, with start and completion dates of scheduled activities.
- o Reference date the estimate was prepared.

Table 7-2 is an example, using a sample project, of calculating total compound escalation to be applied to each scheduled project activity. Escalation accuracy for the total project increases with the number of scheduled activities used in summation.

7.2 Economic Escalation

Economic escalation shall be applied to all estimates to account for the impact of broad economic forces on prices of labor, material, and equipment in accordance with the following requirements:

- o Escalation shall be applied for the period from the date the estimate was prepared to the midpoint of the performance schedule.
- o Since economic escalation rates are revised at least annually, all estimates shall include the issue date of the escalation rates used to prepare the estimate.
- o Costs used for Design Concept shall be fully escalated and referenced as required.

**TABLE 7-1
DEPARTMENTAL PRICE CHANGE INDEX
FY 1990 GUIDANCE
ANTICIPATED ECONOMIC ESCALATION RATES
FOR DOE CONSTRUCTION PROJECTS**

<u>FISCAL YEAR</u>	<u>ENERGY RESEARCH AND NUCLEAR</u>		<u>FOSSIL</u>		<u>CONSERVATION/SOLAR</u>		<u>DEFENSE PROGRAMS, EP, & GENERAL CONSTRUCTION</u>	
	<u>INDEX</u>	<u>% CHANGE</u>	<u>INDEX</u>	<u>% CHANGE</u>	<u>INDEX</u>	<u>% CHANGE</u>	<u>INDEX</u>	<u>% CHANGE</u>
1988	1.000	NA	1.000	NA	1.000	NA	1.000	NA
1989	1.042	4.2	1.043	4.3	1.039	3.9	1.043	4.3
1990	1.092	4.8	1.091	4.6	1.086	4.1	1.093	4.8
1991	1.146	5.0	1.144	4.8	1.138	4.8	1.149	5.2
1992	1.205	5.2	1.203	5.2	1.195	5.0	1.214	5.6
1993	1.274	5.7	1.270	5.6	1.261	5.5	1.285	5.8
1994	1.350	6.0	1.346	5.9	1.333	5.7	1.360	5.8

NOTE:

Based on the materials and labor data contained in the Energy Supply Planning Model and appropriate escalation rates forecasted by Data Resources, Incorporated, it would be expected that DOE projects conform to those rates shown above. Should a submission reflect different escalation rates, supporting documentation should specifically delineate assumptions and the methodology used in developing the escalation rates. DOE Order 5700.3C requires that any local rates different from those above be submitted to the Independent Cost Estimating (ICE) staff for approval, prior to their use. Additional advice and assistance can be obtained from the ICE staff (FTS 896-9697). Until a more specific index is available, the DP index will be used for EM projects.

**TABLE 7-2
ESCALATION COMPUTATION**

Project Title: Example
Location: DOE/AL
Estimate Ref Date: July 1, 1989

STEP 1 - Determine midpoint of scheduled activity.

Scheduled Activity	WBS	Start	Duration Complete	(Months)	Midpoint
1. ED&I Title I	A1A	02/01/90	10/01/90	8 months	06/01/90
2. ED&I Title II	A1B	11/01/90	04/01/90	6 months	01/15/91
3. ED&I Title III	A1C	04/01/91	01/01/95	45 months	02/15/93
4. Equip. Procurement (General Svcs)	B2A	10/01/90	10/01/93	36 months	04/01/92
5. Equip. Procurement (Long-Lead, GFE)	B2B	04/01/91	12/01/91	18 months	08/01/91
6. Facility Const.	B2C	07/01/91	08/01/94	37 months	01/15/93
7. Demolition Work	D1A	01/01/94	09/01/94	8 months	05/01/94
8. Project Mgmt	E1A	02/01/90	01/01/95	59 months	07/15/92

STEP 2 - Select Appropriate Escalation Rates

REF: ICE Rates Issued August 1988, Defense Program Category

FY-1989 = 4.3%	FY-1992 = 5.6%
FY-1990 = 4.8%	FY-1993 = 5.8%
FY-1991 = 5.2%	FY-1994 = 5.8%

TABLE 7-2
ESCALATION COMPUTATION (Cont'd)

STEP 3 - Calculate Appropriate Escalation Rates for Each Scheduled Activity Using Estimate Preparation Date as Starting Point and Apply Escalation Rates Selected in Step 2 to Midpoint Dates Determined in Step 1

1. ED&I - Title I (midpoint = 6/1/90)

<u>FY-Period</u>	<u>Years</u>	<u>x Escalation Index</u>	<u>= Escalation Factor</u>
07/01/89-10/01/89	3/12	.043	.011
10/01/89- 6/01/90	8/12	.048	.032
Compound Escalation Factor = $1.011 \times 1.032 = 1.043 = 4.3\%$			

2. ED&I Title II (midpoint = 1/15/91)

<u>FY-Period</u>	<u>Years</u>	<u>x Escalation Index</u>	<u>= Escalation Factor</u>
07/01/89-10/01/89	3/12	.043	.011
10/01/89-10/01/90	1.0	.048	.048
10/01/90- 1/15/91	3.5/12	.052	.015
Compound Escalation Factor = $1.011 \times 1.048 \times 1.015 = 1.075 = 7.5\%$			

3. ED&I - Title III (midpoint = 2/15/93)

<u>FY-Period</u>	<u>Years</u>	<u>x Escalation Index</u>	<u>= Escalation Factor</u>
7/01/89-10/01/89	3/12	.043	.011
10/01/89-10/01/90	1.0	.048	.048
10/01/90-10/01/91	1.0	.052	.052
10/01/91-10/01/92	1.0	.056	.056
10/01/92- 2/15/93	4.5/12	.058	.022
Compound Escalation			
Factor = $1.011 \times 1.048 \times 1.052 \times 1.056 \times 1.022 = 1.203 = 20.3\%$			

TABLE 7-2
ESCALATION COMPUTATION (Cont'd)

STEP 3 (Continued)

4. Equipment Procurement - General Services (midpoint = 04/01/92)

<u>FY-Period</u>	<u>Years</u>	<u>Escalation Index</u>	<u>Escalation Factor</u>
07/01/89-10/01/89	3/12	.043	.011
10/01/89-10/01/90	1.0	.048	.048
10/01/90-10/01/91	1.0	.052	.052
10/01/91- 4/01/92	6/12	.056	.028
Compound Escalation			
Factor = $1.011 \times 1.048 \times 1.052 \times 1.028 = 1.146 = 14.6\%$			

5. Equipment Procurement - Long Lead GFE (midpoint = 08/01/91)

<u>FY-Period</u>	<u>Years</u>	<u>Escalation Index</u>	<u>Escalation Factor</u>
07/01/89-10/01/89	3/12	.043	.011
10/01/89-10/01/90	1.0	.048	.048
10/01/90- 8/01/91	10/12	.052	.043
Compound Escalation			
Factor = $1.011 \times 1.048 \times 1.043 = 1.105 = 10.5\%$			

6. Facility Construction (midpoint = 01/15/93)

<u>FY-Period</u>	<u>Years</u>	<u>Escalation Index</u>	<u>Escalation Factor</u>
07/01/89-10/01/89	3/12	.043	.011
10/01/89-10/01/90	1.0	.048	.048
10/01/90-10/01/91	1.0	.052	.052
10/01/91-10/01/92	1.0	.056	.056
10/01/92- 1/15/93	3.5/12	.058	.017
Compound Escalation			
Factor = $1.011 \times 1.048 \times 1.052 \times 1.056 \times 1.017 = 1.197 = 19.7\%$			

TABLE 7-2
ESCALATION COMPUTATION (Concluded)

STEP 3 (continued)

7. Demolition Work (midpoint = 05/01/94)

<u>FY-Period</u>	<u>Years</u>	<u>x Escalation Index</u>	<u>= Escalation Factor</u>
07/01/89-10/01/89	3/12	.043	.011
10/01/89-10/01/90	1.0	.048	.048
10/01/90-10/01/91	1.0	.052	.052
10/01/91-10/01/92	1.0	.056	.056
10/01/92-10/01/93	1.0	.058	.058
10/01/93-05/01/94	7/12	.058	.034

Compound Escalation

Factor = $1.011 \times 1.048 \times 1.052 \times 1.056 \times 1.058 \times 1.034 = 1.288 = 28\%$

8. Project Management (midpoint 07/15/92)

<u>FY-Period</u>	<u>Years</u>	<u>x Escalation Index</u>	<u>= Escalation Factor</u>
07/10/89-10/01/89	3/12	.043	.011
10/01/89-10/01/90	1.0	.048	.048
10/01/90-10/01/91	1.0	.052	.052
10/01/91-07/15/92	9.5/12	.056	.044

Compound Escalation

Factor = $1.011 \times 1.048 \times 1.052 \times 1.044 = 1.164 = 16.4\%$

STEP 4 -- The compound escalation factors derived in Step 3 are then applied to the total costs (direct cost + materials and overheads) for each scheduled activity. Total project escalation is the summation of escalation for all project activities.

NOTE: Repetition of calculations is obvious, thus application to a computerized escalation rate analysis forecast program would prove beneficial. Escalation rates applied to scheduled activities are practically tied to the project WBS. Unless a better determination can be made and supported, the midpoint of cash flow for a particular category is set equal to the midpoint of scheduled activity for that category.

CHAPTER 8

8.0 EM-CAT ESTIMATOR'S CHECKLIST

8.1 Introduction

Checklists have been prepared to assist the estimator in evaluating proposed workscopes for completeness, complexity, and accuracy. The checklists are organized to agree with the activities and program phases identified in Chapter 5 of this Handbook and are not intended to be all inclusive, but merely a guide. It is quite possible, and perfectly acceptable, to have an estimate which does not include some of the items on the checklist because those items are not required or are included elsewhere. Ideally, the checklist should be used to facilitate discussion between the estimator and the persons responsible for scoping the project. Space for notes and comments is provided on the checklist but the amount of space should not be interpreted as a limiting factor. The information collected when completing the checklists can be used to complete the Basis of Estimate described in Chapter 3.

The ER program includes many types of remediation activities. Level 3 of the WBS groups remedial activities into three categories based on governing regulations:

1. RCRA: These are remedial activities, including RCRA closures and RCRA corrective measures undertaken to comply with the Resource Conservation and Recovery Act (RCRA), which governs treatment, storage, and disposal of hazardous solid waste.
2. CERCLA: These are remedial activities undertaken to comply with the Comprehensive Environmental Responsibility, Compensation and Liability Act (CERCLA).
3. RCRA/CERCLA: These are activities undertaken where joint regulatory authority (i.e., RCRA and CERCLA) exists.

The checklists are generic and apply regardless of the applicable regulations. However, special notations have been made on the checklists to indicate where regulations could impact cost or scope.

This chapter is intentionally printed single sided for ease of duplication.

EM-CAT Estimator's Checklist

8.2 Assessment Checklists

8.2.1 (PA/SI)/(RFA)

Assessment generally includes two phases. The first phase is designed to evaluate all known information about the site and to conduct a preliminary investigation of the extent and nature of the contamination at the site. The purpose is to determine if further investigation is appropriate. Data collected during this phase is used to build on HRS score for the site. CERCLA refers to this phase as Preliminary Assessment and Site Investigation (PA/SI) and RCRA refers to this phase as a RCRA Facility Assessment (RFA).

The first third of this checklist contains potential scope elements and is to be used to review scope. The second third of the checklist addresses factors which can impact the complexity of the assessment. The final third addresses more general factors that may be applicable to the (PA/SI)/(RFA).

Notes

1. PA/SI Planning and Scoping
2. Background Research on Site
3. Historical Record on Site
4. Documentation Analysis
5. Employee Interview
6. Existing Data Gathering
7. Physical Site Visit
8. Site Characterization
9. Collect Lab Samples (if needed)
10. Laboratory Analysis (if needed)
11. Data Analysis/Evaluation
12. Preliminary Iden. of ARAR's
13. Document Preparation
14. Peer Review
15. PA/SI Report

Comments:

EM-CAT Estimator's Checklist

8.2.2 Site Characterization Factors

Notes

Ground Water

1. Migration Route
2. Observed Release
3. Route Characteristics
4. Containment
5. Waste Characteristics
6. Targets

Surface Water

7. Route
8. Observed Release
9. Characteristics
10. Targets

Air Route

11. Observed Release
12. Waste Characteristics
13. Targets

Fire and Explosion

14. Containment
15. Waste Characteristics
16. Targets

Direct Contact

17. Observed Incident
18. Accessibility
19. Containment
20. Waste Characteristics

Comments:

EM-CAT Estimator's Checklist

8.2.3 Other Factors Applicable to (PA/SI)/(RFA)

Notes

1. Risk Assessment
2. Manhours
3. Travel
4. Equipment
5. Quality Assurance/Quality Control
6. Types of Hazards Involved
7. Personnel Hazards
8. Health Physics Requirements

Comments:

EM-CAT Estimator's Checklist

8.2.4 (RI/FS)/(RFI/CMS)

The second phase of assessment involves a quantitative study of the release site and development of alternative approaches to remediation. These alternatives may range from "do nothing," where a site is not contaminated, to complete remediation. RCRA refers to this phase of assessment as a RCRA Facility Investigation which characterizes the site and a Corrective Measures Study, which considers alternative approaches to remediation. CERCLA refers to this phase of assessment as Remedial Investigation (RI) and Feasibility Study (FS).

Notes

1. Project Planning and Scoping
2. Site Characterization
3. Laboratory/Data Analysis
4. Data Gathering
5. Soil Investigation
6. Community Relations
7. Field Investigation
8. Sample Analysis/Validation
9. Data Evaluation
10. Assessment of Risks
11. Treatability Study/Pilot Test
12. Remedial Investigation Report
13. Remedial Alternatives Screening
14. Remedial Alternatives Evaluation
15. Feasibility Study Reports
16. Post RI/FS Support
17. State Review of Information
18. Miscellaneous Support
19. Expedited Response Action Planning
20. Quality Assurance/Quality Control
21. Training
22. Project Completion & Closeout
23. Expedited Response Action

Comments:

EM-CAT Estimator's Checklist

8.3 Cleanup

Remediation, or site cleanup includes all construction and other field activities necessary to complete the remedial design; however, remediation may not involve cleanup at all. In some cases the waste is left in place and a cap is installed to prevent or limit the leaching influence of rainfall. The first phase of remediation is design. CERCLA refers to this phase as remedial design/remedial action (RD/RA), RCRA refers to this phase as Corrective Measures Implementation (CMI)

8.3.1 Remedial Design

Notes

1. Project Planning and Scoping
2. Design Criteria
3. Design Drawings & Specifications
4. Field Inspection
5. Documentation
6. "As Built" Drawings
7. Operations Manuals
8. Maintenance Manuals
9. Final Reports
10. Permits
11. Quality Assurance/Quality Control
12. Schedule Update and Review
13. Risk Assessment (if required in addition to RI/FS or RFI/CMS activities)

Comments:

The second phase of remediation is the remedial action itself.

EM-CAT Estimator's Checklist

8.3.2 Remedial Activities

Type of Remedy	Notes
1. Containment	
2. Excavation	
3. Treatment	
4. Containerization	
5. Transportation	
6. Disposal	
7. Backfill	
8. Barriers	
9. Site Reclam./Revegetation	
10. Remedial Sys./Monitor. Sys	
Air Monitoring	
Ground Water Monitoring	
11. Treatment Systems	
Leachate Collection	
Other Treatment Sys.	
12. Waste Handling	
Transportation	
Disposal of Treatment Waste	
Handling & Equipment	
Material Movement	
Retrieval System & Equip.	
Waste Certification	
Processing Sys. & Equip.	
13. Water	
Piping	
Pumps, Comp. & Blowers	
Process Piping & Ducts	
14. Air	
Process Piping & Ducts	
Ventilation Systems	
HEPA Filters	
Stacks	
15. Electrical	
Power Conversion & Control	
16. I & C	
Instrumentation	
Instruments & Cntl. Valves	
Cntl. Ctrs. & Computers	
17. Steam and Condensate	
18. Process Systems	
19. Personnel Safety Equipment	
20. Mobilization, Demobilization and Disposal of Equipment Following Completion of Work	

**21. Independent Verification, Final Survey, and
Certification that Work is Complete**

Comments:

EM-CAT Estimator's Checklist

8.4 Items Applicable to Both Assessment and Cleanup Activities

	Notes
Buildings	
1. Storage Sheds	
2. Process Buildings	
3. Decontamination Facility	
4. Size Reduction	
5. Compaction Facility	
6. Support Buildings	
7. Offices	
8. Rest Room Facilities	
9. Change Facilities	
10. Lunch Room Facilities	
11. Site Security	

Comments:

	Notes
Site Support Requirements	
1. Roads, Parking, Fence, Lights, Etc.	
2. Storm Sewers and Drainage	
3. Access Roads	
4. Dikes and Ponds	
5. Erosion Control Devices	
6. Sanitary Sewers and Treatment	
7. Water Supply and Treatment	
8. Supply & Distribution of Power	
9. Water -- Potable & Process	
10. Maintenance & Storage	

Comments:

	Notes
Miscellaneous Factors	
1. Environmental Impact Statements	
2. Liability Insurance	
3. Technical Specialists	
4. Authorizing Bodies	

Miscellaneous Factors, Cont'd.

5. Concerned Groups
6. P.R. & Community Relations
7. Handling Problems
8. Obstructions and Interferences
9. Effluent Specifications
10. Labor Conditions
11. Climate & Weather
12. Training

Comments:

Safety Considerations

Notes

1. Types of Hazards Involved
2. Personnel Hazards
3. Health Physics Requirements
4. Industrial Hygiene Requirements
5. Health and Safety Plan (HASP)
6. H & S Surveillance/Monitoring

Comments:

EM-CAT Estimator's Checklist

8.5 Resource Conservation and Recovery Act (RCRA) Corrective Actions

The following checklist identifies items that should be considered for RCRA closures:

	Notes
1. Closure Performance Standard	_____
2. Closure Plan	_____
3. Time allowed for Closure	_____
4. Disposal or Decontamination of Equipment, Structures, and Soils	_____
5. Certification of Soil	_____
6. Survey Plat	_____
7. Post-Closure Care and Use of Property	_____
8. Post-Closure Plan	_____
9. Post-Closure Notices	_____
10. Certification of Completion of Post Closure Care	_____

Comments:

EM-CAT Estimator's Checklist

8.6 Program Management Checklist

8.6.1 Installation Program Management

Notes

1. Preparing ADS _____
2. Updating the Site-Specific Plan _____
3. Preparing Task Documentation to Plan and Complete Specific Restoration Phase(s)
 - Statement of Work _____
 - Requests for Proposals _____
 - Task Work Plans Including Sampling _____
 - and Analysis Plans _____
 - Health and Safety Plans _____
 - Community Relations Plans _____
 - QA/QC Plans _____
 - Analytical Laboratory QA/QC Plans _____
 - NEPA Plans _____
 - Safety Assessments _____
 - RDDT&E Plans _____
 - Pre- or Postclosure Plans _____
4. Procuring Contractor Services _____
5. Monitoring Execution of Work _____
6. Collecting and Reporting Data Results _____
7. Performing Readiness Reviews, Audits, _____
and/or Surveillances _____

Comments:

EM-CAT Estimator's Checklist

8.6.2	Field Office Program Management	Notes
1.	Provide Program Management Direction	_____
2.	Conduct Program Reviews	_____
3.	Review and Approve M&O Contractor's Installation Management Plan	_____ _____
4.	Review and Approve Functional Management Plans	_____ _____
	Financial Management Plan	_____
	Program Control Plan	_____
	QA Plan	_____
	Data Management Plan	_____
	Systems Engineering Management Plan	_____
	Baseline Management Plan	_____
	OU Transition Plan	_____
	Postremediation/Closure Plan	_____
5.	Develop and Implement Agreements with Federal, State and/or Local Regulatory Agencies	_____ _____
6.	Provide Data to the Program Database	_____
7.	Develop Field Office Priority List for HQ Prioritization System	_____ _____
8.	Prepare Field Office Program Planning, Programming, and Budgeting Information	
	ADSs	_____
	Annual Budget Submittal	_____
	Financial Plan	_____
	SSP	_____
	Current-Year Work Plan	_____
9.	Provide Review and Comment on Installation Program Documentation, Reports, and ADSs.	_____ _____ _____

EM-CAT Estimator's Checklist

10. **Provide Field Office Program Status Reports to the HQ Program Office** _____
11. **Communicate Remediation Technology Needs to Field Office Testing and Evaluation Managers and to HQ** _____
12. **Maintain Public Awareness and Involvement** _____
13. **Perform Readiness Reviews, Audits, and/or Surveillance** _____
14. **Review Remediation Contractor's and Subcontractor's Program Documents (e.g. Program Control QA, and ES & H Plans** _____

Comments:

CHAPTER 9

9.0 CATALOG OF ER DATABASES

9.1 Objective

The objective of this chapter is to present a catalog of data sources and databases available for the preparation of cost estimates and undertaken as part of the DOE Environmental Restoration and Waste Management (ER) Program. The catalog of data and databases should facilitate the exchange of cost information between DOE estimators that would be unavailable or scarce to some groups and to keep data as current as possible to the actual cost experience.

9.2 Discussion

The research conducted in ER data sources and databases reveals that much of the estimating data approach different portions of the ER estimating continuum with varying degrees of emphasis. The type of estimate required and the corresponding degree of accuracy desired within the estimate can serve as a criterion to differentiate among the data sources available. Accordingly, the database information can be either specific or parametric in nature, depending upon the level of accuracy desired or the design stage during which the estimate is generated.

The application of ER database information is frequently through the implementation of an ER cost estimating tool. The manipulation of the estimating tool can readily access ER database information internally and provide a convenient method to extract specific or parametric cost data for integration into a complete cost estimate. Accordingly, a majority of the existing ER cost data sources are currently available through the purchase of ER estimating software tools. For a more definitive evaluation of the ER cost estimating tools and associated databases, see Chapter 10 of this Handbook.

The database information sheets presented herein are a compilation of data from sources within DOE affiliated public and private firms, and other U.S. Government agencies operating in the field of environmental restoration. In many cases, the database information is available only through the use of a computerized ER estimating tool as previously mentioned. It is worthy of note that even through the direct acquisition of a computerized ER estimating tool, access to the cost database itself may be restricted or entirely denied given the possibility of a copyrighted database by the software supplier.

9.3 Catalog of ER Databases

The catalog is presented for informational purposes with only a simplified evaluation provided for the understanding of the basic nature and characteristics exhibited by each of the databases. No attempt is made to rank the validity of performance or the feasibility of each database's cost information in the generation of an ER project estimate. The catalog is divided into two sections. Section 9.3.1 provides information universally available from estimating publications. It is anticipated that as environmental restoration and waste management projects proliferate, estimating publications will become more specialized towards this burgeoning industry. Section 9.3.2 lists information sheet examples of proprietary ER databases currently being utilized by commercial organizations involved with ER projects.

9.3.1 Estimating Publication Databases

Current estimating publications containing ER related cost estimating information are as follows:

R.S. Means Company, Inc.
1000 Construction Plaza
P.O. Box 800
Kingston, MA 02364-0800
(617) 585-7880

Means Site Work Cost Data

Means Construction Cost Data

Means Heavy Construction Cost Data

Richardson Engineering Services, Inc.
1742 S. Fraser Drive
P.O. Box 9103
Mesa, AZ 85214-9103
(602) 497-2062

Richardson Process Plant Construction Estimating Standards

9.3.2 Proprietary ER Databases

The following list of companies responded to inquiries with brief generic descriptions of their own proprietary ER databases assembled through historical cost data obtained by contract performance in remedial action projects. These proprietary databases are mentioned in this section for understanding the nature of the costs collected by environmental restoration contractors. Contractor cost estimates prepared from these databases should contain validated and normalized cost data in order to be universally applicable to other remedial action projects.

PROPRIETARY DATABASES

Bechtel National, Inc.
Oak Ridge, TN

CH₂M Hill
Washington, DC

Chem-Nuclear Systems, Inc.
Columbia, SC

EBASCO Environmental
Lakewood, CO

Engineering-Science, Inc.
Denver, CO

Holmes & Narver
Honolulu, HI

International Technology Corporation
Monroeville, PA

NUS Corporation
Pittsburgh, PA

OHM Corporation
Roswell, GA

Information sheets detailing the above mentioned proprietary databases are appended to the end of this chapter.

9.4 Conclusion

ER databases are variable in the characteristics of the cost data and may not meet all objectives for every use. Database users must have clear objectives for the intended application of the cost data and understand the distinctions between databases with respect to type of estimate required, the corresponding accuracy of the estimate, and the types of containment priced within the cost data.

However, the pervasiveness of inaccurate ER cost estimates has demonstrated the potential importance of these databases in helping to provide better estimates. Standard engineering costing methodologies have been inaccurate in estimating actual remediation costs. This can be attributed, in large part, to the uniqueness of many remediation sites and the greater degree of uncertainty exhibited by these sites. The use of ER databases and/or ER cost estimating tools has the potential to play a major role in improving the accuracy of estimates.

APPENDIX A TO CHAPTER 9
INFORMATION SHEETS FOR PROPRIETARY DATABASES
RELATED TO ENVIRONMENTAL RESTORATION (ER)

**INFORMATION SET FOR
PROPRIETARY DATABASE RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: Bechtel National, Inc.
Jackson Plaza Tower
800 Oak Ridge Turnpike
Oak Ridge, TN 37830

Mail Address:
P.O. Box 350
Oak Ridge, TN 37831-0350

Contact Person: L.R. Goodwin/D.P. Van Hoff

Telephone Number: (615) 576-1740/(615) 576-0989
Plant (615) 482-1552

Description of Database: Approximately 130 ER-related subcontract files are contained in the database. The database is accessed by subject item and unit cost. The costs are derived from proposed bids by various contractors and original estimate proposals by Bechtel National for ER related projects. The database is also manipulated for parametric estimates.

Percentage Composition of Database:

Earthwork	_____
Packaging	_____
Decontamination &	_____
Decommissioning	_____
Equipment Costs	_____
Remedial Investigation/	_____
Feasibility Study	_____
Remedial Design	_____
Remedial Action	_____100%
TOTAL	100%

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: CH₂M Hill
Mid-Atlantic Office
P.O. Box 4400
Reston, VA 22090

Contact Person: Timothy D. Van Epp, Director
DOE/HQ Technical Support

Telephone Number: (703) 471-1441

Description of Database: The database is part of a Work Plan Guidance Handbook providing direction for the preparation of remedial investigation, feasibility studies, remedial design and remedial action work plans and their associated costs.

Percentage Composition of Database: Not known

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: Chem-Nuclear Systems, Inc.
220 Stoneridge Drive
Columbia, SC 29210

Contact Person: Frederick Gardner, Executive Director
Government Programs & Environmental Services Division

Telephone Number: (803) 256-0450

Description of Database: The database is composed of extensive project files detailing the unit costs and manhour records for decontamination and decommissioning environmental restoration efforts. The projects recorded encompass over fifty sites since 1978.

Percentage Composition of Database:

Earthwork	_____
Packaging	_____
Decontamination & Decommissioning	_____100%
Equipment Costs	_____
Remedial Investigation/ Feasibility Study	_____
Remedial Design	_____
Remedial Action	_____
TOTAL	100%

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: EBASCO Environmental
143 Union Blvd., Suite 1010
Lakewood, CO 80228-1824

Contact Person: Robert S. Lytle, Manager
Western Operations Remedial Programs Group

Telephone Number: (303) 988-2202

Description of Database: Multiple databases are maintained for ER cost estimating support in ongoing projects regarding hazardous and nuclear waste environmental restoration assessments remedial design and remedial action.

Percentage Composition of Database:

Earthwork	<u>10%</u>
Packaging	<u> </u>
Decontamination & Decommissioning	<u>10%</u>
Equipment Costs	<u> </u>
Remedial Investigation/ Feasibility Study	<u> </u>
Remedial Design	<u>20%</u>
Remedial Action	<u>60%</u>
TOTAL	100%

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: Engineering-Science, Inc.
1100 Stout Street, Suite 1100
Denver, CO 80204

Contact Person: Richard Anderton

Telephone Number: (303) 825-8100

Description of Database: The ER database used is a compilation of estimating publications (i.e., R. S. Means, etc.) and historical data. The data is accessed by subject unit cost, material, labor, and equipment dollars. Remedial action costs emphasize historical data from extensive project files.

Percentage Composition of Database:

Earthwork	<u>10%</u>
Packaging	<u> </u>
Decontamination & Decommissioning	<u>20%</u>
Equipment Costs	<u> </u>
Remedial Investigation/ Feasibility Study	<u> </u>
Remedial Design	<u> </u>
Remedial Action	<u>70%</u>
TOTAL	100%

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: Holmes & Narver
P.O. Box 29939
Honolulu, HI 96820-2339

Contact Person: Catherine Agegian

Telephone Number: (808) 422-9223

Description of Database: The database is heavily oriented towards design engineering concerning environmental restoration.

Percentage Composition of Database:

Earthwork	_____
Packaging	_____
Decontamination & Decommissioning	_____
Equipment Costs	_____
Remedial Investigation/ Feasibility Study	20%
Remedial Design	80%
Remedial Action	_____
TOTAL	100%

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: International Technology Corporation
William Penn Plaza
2790 Mosside Blvd.
Monroeville, PA 15146-2792

Contact Person: Benjamin J. Kosek, Chief Estimator

Telephone Number: (412) 372-7701

Description of Database: The ER database is composed of data from estimating publications, equipment handbooks, and historical cost records.

Percentage Composition of Database:

Earthwork	<u>75%</u>
Packaging	<u>5%</u>
Decontamination & Decommissioning	<u>5%</u>
Equipment Costs	<u>15%</u>
Remedial Investigation/ Feasibility Study	<u> </u>
Remedial Design	<u> </u>
Remedial Action	<u> </u>
TOTAL	100%

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: NUS Corporation
Waste Management Services Group
Park West Two
Cliff Mine Road
Pittsburgh, PA 15275-1071

Contact Person: Albert M. Finke, Jr.

Telephone Number: (412) 788-1080

Description of Database: The database used is a collection of data from estimating publications (i.e., R.S. Means, Richardsons, EPA Documents,...etc.) and historical data. The cost estimating tool CORA (Cost of Remedial Action), is operated in association with the above referenced data sources.

Percentage Composition of Database:

Earthwork	<u>30%</u>
Packaging	<u> </u>
Decontamination & Decommissioning	<u> </u>
Equipment Costs	<u>35%</u>
Remedial Investigation/ Feasibility Study	<u> </u>
Remedial Design	<u>5%</u>
Remedial Action	<u>30%</u>
TOTAL	100%

**INFORMATION SHEET FOR
PROPRIETARY DATABASES RELATED TO
ENVIRONMENTAL RESTORATION (ER)**

Name/Address of Organization: OHM Corporation
1000 Holcomb Woods Parkway
Suite 112
Roswell, GA 30076

Contact Person: John F. O'Brien or Lonnie E. Reese

Telephone Number: (404) 641-1066

Description of Database: The database contains approximately 300 ER-related items collected from data available in estimating publications and internal historical cost accounting records. The data is accessed by material, equipment, and labor hour dollars per ER subject.

Percentage Composition of Database:

Earthwork	_____
Packaging	_____
Decontamination & Decommissioning	_____
Equipment Costs	_____ 70%
Remedial Investigation/ Feasibility Study	_____
Remedial Design	_____
Remedial Action	_____
Labor Costs	_____ 30%
TOTAL	100%

CHAPTER 10

10.0 CATALOG OF COMPUTERIZED ENVIRONMENTAL RESTORATION (ER) ESTIMATING TOOLS

10.1 INTRODUCTION

The need to accurately estimate hazardous waste cleanup costs has led to the development of several computerized cost estimating tools and models for this type of project. The development of these tools has been sponsored by the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), and increasingly by private industry. The purpose of this report is to develop a framework for categorizing the tools and to provide an overview of the various tools and models already in use and those in the process of being developed.

As the number of cost estimating tools on the market multiplies, the development of a framework for analyzing these tools is necessary. One strategy is to develop a set of categories for assessing the appropriate application of a tool. For example, should the tool be used as an order-of-magnitude estimating tool at the early stages of the project or as a tool for building definitive estimates at later stages of a project? In addition to categorizing the tools, the limitations and inherent biases of these models should be recognized. Some of these tools, for example, do not incorporate modules for examining mixed or radioactive wastes. Unless the user knows the proper application of the tool, the accuracy of the conclusions will be questionable.

This Handbook is in response to the U.S. Department of Energy's need to identify resources available for estimating environmental restoration costs. As a result, the report focuses on tools devoted exclusively to estimating costs at hazardous waste cleanup sites. A list of the tools and their sponsors is shown in Table 10-1. Other more "generic" tools may also be appropriate and will be briefly discussed as well.¹⁷ Since many of the tools under review are still under development, the amount of information on each tool available to the authors varies. Consequently, the length and degree of detail provided on the tools varies as well.

The first section describes the cost-estimating framework for categorizing the various tools. The second section provides a brief overview of each tool organized by the estimating stage at which it is best applied. The third section looks at other generic cost estimating tools that may be applied to environmental restoration projects. Finally, the conclusion offers recommendations on improvements and changes that are needed for the next generation of tools. Appendix C to this chapter includes a summary sheet on each tool.

¹⁷ A good source for general computerized cost estimating tools is R.A. Ressler, W.E. Gallagher, and T.C. Ponder, *Microcomputer Cost Estimating Programs*, Prepared by PEI Associates, Inc. for the Independent Cost Estimating Staff, US Department of Energy, November 1985.

Cost Estimating Tools Examined in Study

Name of Tool	Sponsoring Organization	Tool Developer
Cost of Remedial Action	U.S. EPA	CH ₂ M Hill, Inc.
Freiman Analysis of Systems Techniques (FAST)	U.S. DOE	FPS, Inc.
HAZRISK	U.S. DOE	IPA, Inc.
Liner Location and Risk Model (LLM)	U.S. EPA	ICF, Inc.
Micro-Computer Aided Cost Engineering Support System (M-CACES)	U.S. DOD	Building System Designs, Inc.
RCRA Risk-Cost Analysis Model (WET)	U.S. EPA	ICF, Inc.
Remedial Response Construction Cost Estimating System (PRACES)	U.S. EPA	PEI Associates, Inc.
Remedial Action Assessment System (RAAS)	U.S. DOE	Pacific Northwest Laboratories
Removal Cost Management System (RCMS)	U.S. EPA	Roy F. Weston, Inc.
Superfund Cost Estimating System (SCEES)	U.S. EPA	CDM Federal Programs
Project Tracking for Environmental Restoration (TRAC-ER)	U.S. DOE	Los Alamos National Laboratory

Table 10-1

10.2 COST ESTIMATING FRAMEWORK

The application of the handful of tools examined in this report varies. As a result, a framework for categorizing these tools has been developed. This framework is organized by the following categories:

- o Estimation Stage
- o Environmental Restoration Stage
- o Underlying Methodology
- o Contaminants Addressed

Below, each of these categories is discussed in further detail.

10.2.1 Estimation Stage

The American Association of Cost Engineers (AACE) defines three levels of cost estimating accuracy to reflect the increasing definition of a project. These levels are: order-of-magnitude, intermediate (budget), and definitive. Order-of-magnitude estimates are approximate estimates made without detailed engineering data. Actual costs should be accurate within plus 50% or minus 30% of the estimate. Intermediate estimates are made at the beginning of the design stage and actual costs should be accurate within a range of plus 30% or minus 15% of the estimate. Definitive estimates are defined as estimates made when engineering may be up to 40% completed. The actual cost should be accurate within plus 15% to minus 5% of the estimate.¹⁸

Order-of-magnitude estimates are "ball-park" estimates based on several critical variables. These estimates should give the estimator a point estimate that he/she can be confident of being within a reasonable range of the actual cost. By contrast, intermediate and definitive estimates require a more "bottoms-up" approach. This means a detailed costing of each of the components needed for a remedial action. This approach is more labor intensive and should be utilized at the later stages of a project, such as the remedial design or bid evaluation stage.

Figure 10-1 categorizes the various tools by the design stage at which they are most appropriately applied. All but one of the tools are used during the preliminary project stages to generate order-of-magnitude estimates. The grouping of the tools under this category is not surprising. It is a reflection of the fact that this is the area where there is the greatest need for environmental restoration cost estimating tools. It is also a reflection of the difficulty associated with producing reasonably accurate order-of-magnitude estimates.

The relative lack of effort devoted to developing tools for the latter stages of a project can be attributed to a couple of factors. First, we are still in the middle of the evolution of environmental restoration cost estimating tools. Tools that are currently used for order-of-magnitude estimates, may with later versions, be used to generate intermediate cost estimates. Second, it is easier to use other generic cost estimating tools to estimate environmental restoration costs in the latter stages of a project since a more detailed "bottoms-up" approach is required. (See Section 10.3.5).

10.2.2 Environmental Restoration Stage

For the purposes of this document, the EPA CERCLA/SARA (Superfund) terminology is utilized when discussing environmental restoration stages. Historically, DOE cost estimators have not used a standardized terminology when referring to environmental restoration project stages. Since DOE will be adhering to both CERCLA/SARA and RCRA regulations, it is important to note the similarity in project stages between these

¹⁸ Zaheer, S.H., "Contingency and Capital Cost Estimates," *American Association of Cost Engineers, Cost Engineer's Notebook*, American Association of Cost Engineers, Morgantown, WV, revised November 1989.

two regimes and between generic, environmental restoration, and DOE 4700.11 terminology.¹⁹ Figure 10-2 shows the relationship between project stages for these four regimes and the corresponding goal of each stage.

CERCLA/SARA projects have two dominant stages: the remedial investigation/feasibility study (RI/FS) stage and the remedial design/remedial action (RD/RA) stage. The RI determines the nature and extent of the problem represented by a release. This is accomplished through data collection and site characterization. The FS is done concurrently with the RI. It develops and evaluates options for remedial action at a site. The RD is the preparation of the detailed plans and specifications for the implementation of the RA. The RA is the physical action taken to prevent or minimize threats to public health and welfare and the environment at a site. Figure 10-3 presents a time-line showing the evolution of an environmental restoration project. Each distinct stage of a project is identified beginning with the discovery of a site and continuing until the a remedial action is completed. The figure highlights the various stages of a project for applying tools for estimating both RI/FS and RD/RA costs. The top half of the figure shows that an order-of-magnitude cost estimating tool for the RI/FS stage of an environmental restoration project is best applied at the preliminary assessment/site investigation stage. To date, there are no intermediate or definitive estimating tools for costing the RI/FS stage. Three RI/FS order-of-magnitude cost estimating tools are the SCEES and the *HAZRIISK*, and the FAST models.

As shown in the bottom half of Figure 10-3, many more tools are available for costing the RD/RA stage of a project. Order-of-magnitude tools are best applied at the feasibility study or earlier stage of a project. By contrast, the intermediate and definitive tools are a more detailed costing of each of the components needed for a remedial action. This approach requires detailed data and should be utilized at the later stages of a project such as during remedial design or at the construction bid evaluation stage.

10.2.3 Underlying Methodology

The two basic underlying methodologies for the cost-estimating tools investigated are detailed methods and parametric approaches.²⁰ Most of the tools discussed in this report use a detailed approach by relying on unit cost databases for estimating costs. These programs access and extract information from the cost database and modify the data to create an estimate. Cost modules are built from this process and, when aggregated, form the cost estimate. The programs allow the user to manipulate or modify the cost estimate database by changing key cost parameters or default values for a site. The cost modules are derived from the remedial technology chosen.

By contrast, several of the tools rely on the historical costs of previous remedial actions to build parametric cost relationships. These methods link cost and schedule outcomes using parametric statistical techniques such as correlation and simple and multiple regression. Figure 10-4 shows the corresponding system flows between the two types of models. The figure underscores the fact that while both types of approaches start with historical costs, the detailed method uses historical costs to build a unit cost database. Both the knowledge and the procedures for aggregating component costs are contained in the unit cost database. Conversely, with the parametric approach, the expertise for cost estimating projects is embedded in the models and the relationships are established with the historical data.

¹⁹ CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act), also known as Superfund, gives the Federal Government the authority to clean up inactive hazardous waste sites and respond to spills of hazardous substances. While CERCLA can apply to active production and hazardous waste sites, the majority of sites covered by CERCLA are inactive. RCRA (Resource Conservation and Recovery Act) sets standards for generators and transporters of hazardous waste and for owners and operators of hazardous waste treatment, storage, and disposal facilities. RCRA applies mainly to active hazardous waste facilities.

²⁰ Parametric methods include Cost-Estimating Relationships (CER'S), CER's with factor prices, and Compounded CER's. For more information, see L.A. Gasperow, J.W. Hackney, and K.K. Hudson, *Parametric Cost Estimating: A Guide*, Prepared for the Project Management Division, Assistant Secretary for Defense Programs, U.S. Department of Energy, Aug. 1987.

Cleanup Estimating Tools Categorized By Project Stage

Figure 10-1

Comparison of Terminology for an Environmental Restoration Project

Figure 10-2

Application of Tools by Environmental Restoration Stage

Figure 10-3

10.2.4 Contaminants Addressed

There are three major classes of waste at DOE sites: hazardous chemical wastes; mixed chemical and radioactive wastes; and radioactive wastes. Since the majority of the tools examined in this report were built for the EPA, only four of the tools (which are still under development) examine mixed or radioactive wastes. Figure 10-5 organizes the tools by the class of contaminants addressed.

10.2.5 Summary

Figure 10-6 summarizes the classification of the tools. Several tools, such as the Removal Cost Management System (RCMS) and the two ICF models (WET and LLM), did not fit the typology. These tools are discussed later in this report in Section 10.3.4. Notably absent from this chart are intermediate and definitive tools for mixed and radioactive waste cleanups. Also, it is important to note that many of these tools are still under development (e.g., HAZRISK, TRAC-ER, RAAS) and currently are not available. (The HAZRISK Model will be available in April 1990.)

10.3 SHORT SUMMARIES OF ESTIMATING TOOLS

A short summary of each estimating tool is provided below. The summaries for environmental restoration cost estimating tools are organized by the type of estimate generated by a tool. In addition, sections on other computerized environmental restoration cost tools and generic cost estimating tools are also provided. This section is organized as follows:

- o Order-of-Magnitude Environmental Restoration Estimating Tools
- o Intermediate Environmental Restoration Estimating Tools
- o Definitive Environmental Restoration Estimating Tools
- o Other Environmental Restoration Cost Tools
- o Generic Cost Estimating Tool

10.3.1 Order-of-Magnitude Environmental Restoration Estimating Tools

10.3.1.1 Cost of Remedial Action Model (CORA) -- CORA was developed in 1985 by CH₂M Hill to estimate the remedial action costs associated with Superfund sites. The development of the tool was funded by the EPA and was validated by ICF, Inc. EPA routinely uses CORA to build budget estimates of remedial action costs at Superfund sites. In fact, prior to out-year budget submissions, a team visits each regional office and applies CORA for every site where a detailed estimate does not exist. As a result, CORA is probably the most widely used cost-estimating tool in the field. It effectively serves as the industry benchmark against which other cost-estimating tools are judged.

CORA contains both a technology system and a cost estimation system designed to be used independently on a microcomputer. The technology system interacts with the user and provides a number of remedial action scenarios that are likely for the site in question. The system can recommend one or several of 42 cleanup technologies for separate waste matrices. The cost system contains cost modules that can be thought of as building blocks to build up cost estimates for the various site remedial actions recommended by the expert system.²¹ The cost system develops order-of-magnitude cleanup costs based on 42 technology-based cost modules.

²¹ United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Cost of Remedial Action Model: Users Manual*, Prepared by CH₂M Hill, Contract 68-01-7090, June 30, 1988.

CORA has several advantages. First, it is user-friendly and easy to learn. Second, an estimate can be generated quickly if the required data inputs are available. Finally, it allows for the change of key cost parameters in order to develop alternative scenarios at a given site.

However, there are some limitations with the model. The model cannot address radioactive, mixed ordinance, or rad/hazardous (mixed chemical and radioactive wastes) waste sites. Also, CORA is intended to be used as an overall budgetary planning tool for upper-management as a way of understanding total programmatic costs. At a site-specific level, the estimates lose their precision.

Major use of CORA, for example, has been made by the U.S. Navy for estimating funding at an aggregate level. During the summer of 1988, CORA was applied to 661 Navy Installation Program sites. The costs were used by Navy personnel to estimate Defense Environmental Restoration Act funding for fiscal years 1989, 1990, and 1991.²² The model is also in widespread use in the private sector.²³

In January 1989, ICF, Inc., delivered "Performance Evaluation of Cost of Remedial Action (CORA) Model," to EPA's Hazardous Site Control Division.²⁴ ICF examined CORA's cost estimation system to compare costs estimated by CORA with actual, historical costs of remedial actions. ICF concluded that CORA performed well on both an overall budget and site specific basis. In version 1.0 of CORA, nine of the twelve site cost estimates that were evaluated fell within the acceptable range of -40% to plus 60%. However, a closer examination of the results reveal that on average, the nine sites were 12% overestimated and fell within a range of 7% underestimated and to 31% overestimated. In other words, if one were to rely on the results of this validation, on average 12% should be subtracted from the CORA estimates to equate them with actual project costs. In addition, it should be noted that the sites validated were all limited to three EPA regions and chosen if they represented the more costly technologies. This may explain the overestimation bias of the sample. Version 2.1 of CORA was validated by CH₂M Hill in 1988 using the same methodology and sites used by ICF, Inc. In this exercise, 12 out of 12 sites fell within the acceptable range of -30% to plus 50%.

10.3.1.2 FAST Models. The FAST (Freiman Analysis of Systems Techniques) models are a set of parametric cost estimating tools oriented towards order-of-magnitude estimating.²⁵ The models provide a framework for assessing costs when there is limited project design information and few precedents. There are six FAST models (Equipment, Construction, Funding, Mining, Productivity, and Cost of Ownership). For environmental restoration projects, the equipment model (FAST-E) and the construction model (FAST-C) are the most appropriate. For Operations and Maintenance, the Cost-of Ownership model, FAST-CO is appropriate. In addition, FAST-CO can be used to estimate clean-up costs as a cost category in estimating total life cycle costs. FAST-E is an equipment estimating model which is PC-based. FAST-E uses a combination of seven technology types (electronic, electrical, heat, motion, mechanical control, containment, and support) to characterize a piece of equipment. Performance requirements can be specified; for example, volume of gloveboxes, length or weight of cable, etc. The inputs permit the "expression of the fundamental parametric relationships among cost, weight (which can be input or calculated by the model), and technological complexity in a computerized mathematical

²² Richard K. Biggs, Kevin Klink, Jacque Crenca, "The Cost of Remedial Actions (CORA) Model: Overview and Applications," HAZMACON '89 Conference, Santa Clara, CA, April 1989, p. 5.

²³ CORA can be purchased for \$275 from CH₂M Hill. See summary sheet on CORA in the appendix for more details.

²⁴ ICF, Inc., *Performance Evaluation of Cost of Remedial Action (CORA) Model*, Prepared for the U.S. Environmental Protection Agency's Hazardous Site Control Division, January 13, 1989.

²⁵ A more detailed discussion of the FAST models can be found in Lesley A. Gasperow, John W. Hackney, and Kay K. Hudson, *Parametric Cost Estimating: A Guide*, Prepared for U.S. Department of Energy, Assistant Secretary of Defense Programs, Office of Project Management, August 1987.

Distinctions in Underlying Methodologies for Cost Estimating Tools

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Figure 10-4

Classification of Tools by Contaminants Addressed

	Hazardous Chemical Waste	Mixed Radioactive & Chemical Waste	Radioactive Waste
CORA	■		
FAST	■	■	■
*HAZRISK	■	■	■
LLM	■		
*MCACES	■		
WET	■		
*PRACES	■		
*RAAS	■	■	■
RCMS	■		
SCEES	■		
*TRAC-ER	■	■	■

*Tool under development

Figure 10-5

Classification of Environmental Restoration Estimating Tools for Non-Radioactive Materials

	Design Stage			Underlying Approach		ER Application		
	Order-of-Magnitude	Budget	Definitive	Unit Cost	Historical	FI & FS	Remedial Design and Construction	O&M Costs
CORA	■			■			■	■
FAST	■	■			■	■	■	■
*HAZRISK	■				■	■	■	
SCEES	■			■		■		
*PRACES		■		■			■	■
*M-CACES			■	■			■	
*RAAS	■			■			■	
*TRAC-ER		■	■	■		■	■	

*Tool under development

Figure 10-6

equation.²⁶ For environmental restoration projects, the following may be suitable for analysis by FAST-E: (1) glove-box decontamination and decommissioning projects; and (2) large pieces of equipment removal or (3) to estimate the cost of equipment (e.g., incinerators).

FAST-C is a computerized model for calculating the costs, schedules, and risks of all types of civil engineering projects. FAST-C is currently being converted from a mainframe to PC-based. Complexity values are used to account for the various conditions that cause cost variations. The FAST-C models take into account the following factors: economics; economies of scale; site/productivity indices; environmental conditions; operational use of buildings; year of technology; and factor data. Environmental projects that include soils work or that involve any structural activities could use the FAST-C model.

The FAST models are flexible, permit effective costing of design as well as connective and support systems, and provide a measurement of cost risk appropriate at the preliminary design stage and relevant to conventional construction risk. The FAST models, however, do not include data on specific cost aspects of projects. In other words, there is no specific information on the costs associated with environmental restoration projects. The models must be calibrated by the user based on historical (or estimated) cost of at least one project that is similar to the project the user is estimating. To date, there is no formal documentation on the use of the model for environmental restoration projects.

10.3.1.3 IPA's HAZRISK Model. The HAZRISK model is a set of tools currently under development by Independent Project Analysis, Inc. to estimate cost, cost risk and schedules for both the remedial investigation/feasibility stage (RI/FS) and remedial design/remedial action (RD/RA) stage of environmental restoration projects. These tools will assess the cost and schedule risks or contingencies associated with hazardous waste cleanup, including cleanups conducted under CERCLA/SARA (Superfund), RCRA, and cleanups conducted outside of CERCLA and RCRA enforcement. IPA is building these tools based on a database of historical costs and schedules for completed remedial actions. IPA's database will include DOE, EPA Superfund, DOD, and private industry sites on approximately 150 projects. IPA's HAZRISK project is being jointly sponsored by the DOE and a consortium of private sector companies. IPA's approach involves the systematic linking of cost and schedule outcomes (cost growth and schedule slip) with project characteristics such as the nature of the site, the contaminant(s) involved, the technologies selected, the characteristics of the Federal, state, and local regulatory regimes, etc.. The links are forged using parametric statistical techniques such as correlation and simple and multiple regression. These techniques are powerful extensions of the plots and cost-capacity curves familiar to all cost engineers. These techniques have been used with considerable success to gauge the cost growth, schedule slippage and performance difficulties to be expected in first-of-a-kind process plants, in megaprojects, in hydroelectric projects and many other applications. They are appropriate in situations where there are substantial uncertainties in the definition of projects and technologies to be applied.

A key advantage to the HAZRISK model is its ease of use. A user will need to gather only a few key data inputs from a site. The user can then incorporate these into a model and get a cost or schedule estimate that he can be confident of being within a reasonable range of the actual cost. IPA's approach is focused on identifying the key drivers of costs from the historical database. This method allows the user to concentrate on gathering accurate information for the relatively few data inputs that will be needed.

10.3.1.4 Remedial Action Assessment System (RAAS). RAAS is currently under development for DOE's Office of Environment, Safety, and Health, by Pacific Northwest Laboratory. RAAS is designed to be used during the RI/FS stage as a computer based advisory tool to screen and evaluate remedial action alternatives. RAAS will work in tandem with the Multimedia Environmental Pollutant Assessment System (MEPAS) in order to focus on and prioritize the environmental issues at a waste unit.²⁷ It will be, in effect, a total screening advisory tool

²⁶ Ibid, p.25

²⁷ Gene Whelan and Kenneth Hartz, "A Brief Summarization of the Remedial Action Assessment System (RAAS)," Prepared for U.S. Department of Energy, Office of Environment, Safety, and Health, February 5, 1989, p. 1.

as it will have the capacity to identify health risks and environmental damage as well as recommend remedial alternatives and estimate the remediation costs associated with a site.

RAAS will consist of a database containing various treatment technologies. The system applies a set of rules and algorithms to the database in order to screen and link retrieval, separation, treatment, and disposal technologies into remedial alternatives. Costs will be calculated based on algorithms associated with each remedial technology.

The database will be organized into an array of unit process characteristics. A simplified version of this array is shown in Table 10-2.²⁸

Array of Project Characteristics for RAAS Model				
<u>Treatment Mode</u>	<u>Treatment Method</u>	<u>Process Treatment Objective</u>	<u>Performance Characteristics</u>	<u>Cost</u>
In site	Biological	Destruction	Effectiveness	Capital
At grade	Chemical	Encapsulate	Reliability	Maintenance
Off-site	Physical	Confidence	Operating	
	Thermal	Disposal	Implementability	

Table 10-2

10.3.1.5 Superfund Cost Estimating Expert System (SCEES). SCEES has been recently developed by CDM Federal Programs Corporation to estimate the costs of the Remedial Investigation/Feasibility Study (RI/FS) stage of a Superfund site cleanup. The development of the tool was funded by the EPA and is currently being refined through experimental use and validation. The validation of the tool is progressing, supervised by the firm of Booz, Allen, & Hamilton. Like CORA, SCEES uses site specific data information to estimate costs. However, SCEES was developed to estimate the costs of the RI/FS and not the remedial action cost as the CORA model does.

SCEES is a menu-driven system that walks the user through the steps of assessing an RI/FS. As with the CORA and HAZRISK model, special training is not required to run the system but a thorough knowledge of hazardous waste cleanup and site specific knowledge is required.

Since SCEES has just been completed, the accuracy of its estimates is not available. It should be noted that the tool was originally designed to estimate the RI/FS costs of landfill and groundwater contaminated sites. However, the EPA Regional Offices are asking for the development of additional modules to cover other types of cleanup efforts.

²⁸ Kenneth Hartz and Gene Whelan, "MEPAS and RAAS Methodologies as Integrated into the RI/EA/FS Process," *Proceedings of Superfund '88*, Washington, DC, November 1988, pp. 295-299.

10.3.2 Intermediate Environmental Restoration Estimating Tools

10.3.2.1 PRACES. PRACES is being developed by PEI, Inc. for the EPA Risk Reduction Engineering Lab (RREL). A "quasi-design" system, the program allows the user to model costs at a component level. The system is structured to cost out remedial technologies and actions at a site on a line-item approach and relies upon a unit-cost, cost estimating relationship (CER), and operations and maintenance item database. Use of this tool will be most effective at the later stages of estimating a project, such as the design stage, when such detailed data would be available. PRACES allows the user the option of generating order-of-magnitude estimates, however. Most modules include default values for various parameters. Thus, even when site specific data are not available a user can still get a "ball-park" estimate.

Its intended use is broader than any of the other tools under review. They include the following:

- o Develop scoping costs for budget planning
- o Calculate specific remedial site costs
- o Check estimates performed by others
- o Compare alternative technologies
- o Evaluate costs proposed by potentially responsible parties
- o Perform value engineering analysis

The novice user is guided through a series of menus that enables the user to explore the various technology components that may be applicable for a site. Experienced users may directly select a technology without exploring the menus. After selecting a technology, the user then enters the design parameters which calculate the cost for each technology component or subassembly. These sub-assemblies are eventually aggregated to give the total site cleanup cost. The database stores the unit costs or cost equation coefficients for each line item. The menu hierarchy and an example are shown below:

		<u>Example</u>
o X.	Major program subdivisions	2. Treatment Technologies
o X.X.	Technology categories	2.2 Direct Waste
o X.X.X.	Specific technologies	Treatment Methods
o X.X.X.X.	Technology subcategories	2.2.3 Physical Methods
o Data input within X.X.X.X.	Subcategory modules and subassemblies	2.2.3.2 Carbon Absorption

Furthermore, a job input file is contained within the system that allows the user to bring up data files and adjust past runs without having to re-enter data.²⁹

PRACES is an excellent tool when a preliminary "bottoms-up" cost estimate for an action is needed. The level of detail required in order to ensure accurate estimates means that PRACES is best used at the later stages of the design process when such data is available. Scoping costs at an early stage with PRACES may require an over reliance on default values incorporated in the cost modules and/or user assumptions and lead to loose estimates. Further, PRACES does not have the capability to generate the amount of contingency needed for a project, (i.e. users input a percentage for contingency). As a result, these estimates must depend on the best guess of the estimator.

10.3.3 Definitive Environmental Restoration Estimating Tools

10.3.3.1 Project Tracking for Environmental Restoration (TRAC-ER). This system is currently used to produce definitive baseline costs and schedules for the ER program. It relies on a unit cost database that can be augmented with historical unit costs. Currently, this system is in the working prototype stage and is installed at four DOE sites under the Albuquerque Operations Office.

²⁹"A Modular Computerized Cost Model for Remedial Technologies at Superfund Sites," PEI Associates, pp. 3-10.

10.3.3.2 Micro-Computer Aided Cost Engineering Support System (M-CACES). Micro-CACES was developed by the Savannah District of the Corps of Engineers in 1987 as a micro-computer version of CACES. M-CACES is a detailed "bottoms-up" construction cost-estimating tool typically applied to heavy civil projects, new building construction, process plants, and rehabilitation projects. CACES is oriented towards lump-sum contracts. The Corps is in the process of building an environmental restoration unit cost library so that both the mainframe and micro version of CACES can be used for hazardous waste cleanup projects.

The primary purpose of the system is to prepare detailed cost estimates for building construction and related sitework. Currently, the database (CACES Unit Price Book) is being expanded to include heavy civil works line items and software modified to better handle heavy construction projects. The system has been applied to process plants. The Job Order Contracting (JOC) system is an adaptation of the original CACES and the Unit Price Book is used for operation and maintenance contracts at Army installations. The CACES system provides standardized formats, in-depth cost analysis through detailed summaries, rapid execution of changes and data manipulation, electronic transmission of estimates, historical means to monitor cost changes, timesaving management vehicle to control Architect-Engineer support, and expedient and accurate cost estimating techniques.³⁰

In addition, even though M-CACES is a "bottoms-up" detailed construction cost estimating tool, the Corps is presently adapting the Control Estimate Generator (CEG) from the mainframe computer to the microcomputer environment. The CEG is a budgetary estimating tool which uses 44 building models and sitework assemblies to replicate a detailed quantity takeoff which can be processed through the existing M-CACES estimating system to provide a detailed construction cost estimate at incomplete design stages.

10.3.4 Other Computerized Environmental Restoration Cost Tools

10.3.4.1 Removal Cost Management System (RCMS). RCMS was developed by Roy F. Weston, Inc. for the Emergency Response Division of EPA. RCMS is a cost management tool for Federal On-Scene Coordinators (OSCs). Its purpose is to allow OSCs or project managers to effectively track costs of emergency removals on a real-time basis in order to minimize unnecessary costs. The user tracks costs by entering known data inputs. The system also has the facility to estimate future costs. This part of the system, however, is not very sophisticated and is still in the process of being developed. As a result, the best use of this system is for tracking costs to ensure that resources are being used effectively.

10.3.4.2 Liner Location and Risk Model (LLM) and the RCRA Risk-Cost Analysis Model (WET). Both the LLM and WET are mainframe systems developed for EPA's Office of Solid Waste by ICF, Inc. They are primarily intended to be used as policy analysis tools in order to evaluate various technical control options for land disposal facilities. The models serve as a way to identify risk and cost differences for various combinations of facility design, location, and waste type.

The LLM is applicable to land disposal sites (i.e., landfills and surface impoundments) and estimates the health risks and costs associated with various corrective actions and location scenarios. The LLM contains a cost sub-model that estimates cleanup costs based on liner design and size, remedial technology, plume size, and clean-up targets. The model requires that the user input a number of variables for each model run. These include chemical or waste identity and disposal quantity, facility design type and size, climate, groundwater flow, distance from facility to exposure point, and exposed population size. The system contains unit cost data and estimates costs based on a set of algorithms.

³⁰"Computer Aided Cost Engineering Support System: Description and Overview," U.S. Army Corps of Engineers.

Similar to the LLM model, the WET model is used for evaluating the health risks and costs associated with different waste management technologies at RCRA sites. The model is designed so that it can be structured or altered to incorporate different regulatory specifications. Thus, the different effects of alternative specifications can be identified. Default values and parameters can be changed for sensitivity analyses. The model consists of an array of possible ways to treat, store, and dispose of hazardous wastes. These possible waste management practices are formulated by combining three factors: 1) waste stream, 2) technologies to treat, transport, and dispose of the wastes, and 3) the environmental setting in which the wastes are managed.³¹ The model then calculates the health risks and costs associated with each waste management practice.

These models appear useful for policy purposes when evaluating the risk and cost implications of different waste management practices (including remedial technologies). However, they are not intended for estimating the risks and costs at a specific site. Rather, their primary purpose is to examine the policy implications of various regulatory control options and corrective actions at an aggregate national level.

10.3.5 Generic Cost Estimating Tools

In addition to cost-estimating tools devoted exclusively to environmental restoration projects, other generic tools may also be appropriate for estimating cleanup costs. These tools have the capability to estimate costs primarily at either the intermediate or final stages of hazardous waste cleanups since the unit costs needed at this stage operate at the same disaggregate level. The tools listed also allow the user to input unit costs. This gives the user the flexibility to add unit cost data that is applicable to environmental restoration projects. The estimator can tailor the estimate to the peculiarities of his/her site.

10.3.5.1 COSTPRO. COSTPRO is a generic cost estimating system that can be used to prepare cost estimates on projects from the planning stage through detailed design. The code is a complete commercial rewrite of the Los Alamos National Laboratory's mainframe cost estimating system and, by virtue of its origin, is particularly well adapted to preparing estimates for DOE projects. One of the strengths of the system is its ability to manage up to four different work breakdown structures simultaneously without re-entering the basic cost estimate takeoff data. This is particularly helpful in instances where multiple format reporting may be required or where reporting requirements are not known in advance or can be expected to change over the life of the project.

The model creates two basic files: a takeoff file which contains all quantities and direct costs, and a factors file which contains indirect cost factors, work breakdown structure codes, and estimate notes. A convenient feature allows the user to customize the cursor movement to highlight only those fields desired which saves time and effort when revising costs or updating the estimate. "What if" scenarios can be evaluated using a flag to turn estimate items "on or off" allowing consideration of multiple alternatives. Reports can be printed to the screen and previewed to the screen if desired to save time and paper.

The model has a database manager that allows the user to build custom databases of his/her own and to use databases created by others (such as CACES). Databases can be simple such as a list of crew rates or bulk material prices; or complex such as assemblies of labor, material, and equipment for concrete walls. If the database is used to prepare an estimate, the program cross references the database item in the estimate.

10.3.5.2 G2 Estimator. G2 Estimator was developed by G2 Inc. as a cost estimating system that provides the user with great flexibility to tailor the work environment as needed. The software comes with default values and work codes already defined but can be redefined if desired. Data can be input in almost any manner using worksheets. Estimators use a cloning tool to pick up information from other estimates or from other parts of the current estimate. Cloning can also be used to adapt and upgrade the original bid estimate for different phases of the project, all the way through the operations and maintenance phase. Another tool, mergers, lets

³¹ Personal Communication, ICF, Inc., October 16, 1989.

the lead estimator divide an estimate into any number of smaller sections, distribute the work, and then recompile the pieces, with any conflicts identified.³²

The National Construction Estimator is the standard database provided with the system. However, other commercial databases are provided as an option. Along with estimated cost and resources summaries, reports can include bar charts, graphs, and tables and can provide a time-phased project model.

10.3.5.3 Precision Estimating Plus. Precision Estimating Plus was developed by Timberline Software Corp. and combines the features of an electronic spreadsheet with an estimating system. It uses point-and-press windowing to allow the estimator to: (1) create and/or select items, phases and crews; (3) show item details and totals; and (4) perform work package take-off. A range of databases is available with the software to meet the specific needs of the estimator. The package interfaces with a variety of digitizers, has an expanded audit trail with dimensional take-off information and includes a custom report writer. The program has the capability to interface with developer's other project and accounting software.

10.4 CONCLUSIONS

Computerized cost-estimation tools can play a major role in improving the speed and accuracy of projecting hazardous waste cleanup costs. Problems and weaknesses with existing tools and models are a reflection of the relative infancy of computerized cost-estimating tools for hazardous waste projects. Some conclusions from this review and some recommendations for the next generation of tools and guidelines for DOE in reviewing and assessing new tools as they are developed are summarized in the following sections.

10.4.1 Recommendations for Next Generation of Tools

Tools should have clear objectives for their intended use.

Before developing a tool, there should be a clear focus on the use of the tool. That is, whether a tool is intended for order-of-magnitude and "ball-park" estimates or whether a tool is intended for detailed budget and definitive estimating for project cost control and manager accountability. In many respects, CORA and PRACES encompass a little bit of both worlds. PRACES, for example, can best be described as an intermediate tool that, with later versions, will move in the direction of more detailed definitive estimating. CORA, on the other hand, is as an order-of-magnitude "ball-park" estimating tool developed primarily for budgetary purposes.

Each tool should undergo a comprehensive verification and validation study.

Since many of these tools are under development, an extensive testing and validation study of the tools should be completed. The mechanics of the software should be complete and operate properly. The software should be properly sequenced. For example, it should move from module to module correctly and the menu hierarchy should be logical. Also, the accuracy of the tool should be tested by an unbiased validation sample. The sample should be random and include sites which encompass different remedial technologies.

Tools should learn from each estimating experience.

As actual cost data is made available, the tools should easily incorporate this data into building new cost estimates.

³²"Estimator Respects Quirks of Individuals," *ENR*, January 12, 1989, p. 24.

The next generation of tools should use the current group of tools as building blocks for their development.

Instead of working at cross-purposes, newer cost-estimating systems should encompass the best features of existing tools and add improvements and modifications.

Tools should be applicable to wide range of sites.

A tool should be applicable for sites with diverse remedial technology requirements. That is, its use should not be limited to sites characterized by certain conditions or technologies.

Tools should identify key data items.

A tool should clearly identify the primary cost drivers of a project. Given limited resources, a user needs to know where to concentrate his data gathering efforts.

Point estimate checking tools should provide meaningful range of uncertainty.

A user should be confident that an estimate generated by a tool lies within a reasonable range of the actual cost. A confidence range that is too broad minimizes the effectiveness of the tool.

Unit cost numbers should be made available to the estimators.

Unit cost numbers used by a tool in generating an estimate should be easily accessible by the user. Most of the unit cost-based tools examined in this study shield these numbers. The estimator should have the option of changing these unit costs if necessary.

10.4.2 Recommendations for U.S. Department of Energy

In reviewing and assessing environmental restoration tools, DOE should continue its review effort by building upon the framework established in the first section of this report. Procedures should be established to test:

- o Applicability of the tool to DOE sites
- o Ability of the tool to meet DOE needs
- o Type of estimate generated by the tool
- o Results of validation studies on the tool

In addition, environmental restoration tools developed for the DOE should incorporate the relevant work of other CAT Sub-Task Groups. More specifically, they should use standardized terminology and structure developed by the various groups. These Sub-Task Groups are:

- o Sub-Task Group on Guidelines for RI/FS, Program Project Management, etc.
- o Sub-Task Group on Guidelines for Contingency Application
- o Sub-Task Group on Cost-Estimating Formats
- o Sub-Task Group on Dictionary of Terms
- o Sub-Task Group on Guidelines for Escalation Application

Implementing this type of framework and incorporating the work of the CAT Sub-Task Groups in the development of tools will have several benefits. First, it will help ensure that a tool is applicable to DOE sites and able to generate accurate cost-estimates depending on the type of estimate needed. Second, including standardized structures and terminology helps to ensure consistent estimates across sites and provides a basis for meaningful comparisons. Finally, the implementation of the above procedures will take into account the concerns and recommendations of DOE cost estimators and promote the use of environmental restoration tools by the DOE cost-estimating community.

This overview also highlighted two major areas in which DOE needs to invest more resources. These are in the validation of current and future tools and in building unit cost databases for both the mixed (radioactive and chemical) and radioactive waste areas. So far, only CORA has been validated. As other tools are made available to DOE, they should be validated in order to judge their performance and accuracy. In addition, since the majority of DOE environmental restoration sites are characterized by either mixed or radioactive waste, the building of unit cost databases in this area is essential for generating intermediate and definitive cost-estimates.

APPENDIX A TO CHAPTER 10
Unit Cost Sources

APPENDIX A TO CHAPTER 10

Unit Cost Sources

Often, estimators do not have access to hazardous waste cleanup estimating tools or models. A good starting point in these cases are unit cost references. Some of the more commonly used sources include R.S. Means, Richardson Engineering Services, and Walker's Estimating and Construction Journal. In fact, PRACES incorporates unit costs from both R.S. Means and Richardson Engineering. In addition, the CAT Sub-Task group on databases has recently produced a report on environmental restoration databases (see Chapter 8). However, due to unique problems and uncertainties encountered in remedial actions, standard engineering costing methodologies are not always appropriate. A more accurate source may be the "Compendium of Costs of Remedial Technologies at Hazardous Waste Sites," developed by the Environmental Law Institute for the EPA. This source is devoted exclusively to capturing costs associated with hazardous waste cleanups. The purpose of the report was to calculate "bottomline" numbers for remedial actions for seven major types of engineering technologies. Data supporting the compendium are drawn from 31 case studies of remedial actions. The report also examines the divergence between actual remedial costs and estimates from existing engineering cost methodologies. See: Edward C. Yang, et al., *Compendium of Costs of Remedial Technologies at Hazardous Waste Sites*, Prepared for the Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, EPA/600/2-87/087, October 1987.

APPENDIX B TO CHAPTER 10
Non-Computerized Cost Estimating Methods
For Environmental Restoration Projects

APPENDIX B TO CHAPTER 10

Non-Computerized Cost Estimating Methods for Environmental Restoration Projects

Several non-computerized methods have been developed for estimating cleanup costs at hazardous waste sites. Two of the more interesting ones are the Cleanup Cost Allocation Model (CAA) and the Remedial Cost Estimation System (RCES).

The CAA is an equitable cost-allocation mechanism developed in response to a potentially responsible party's (PRP) request. The industry wanted a rational cleanup cost allocation model applicable to any waste site. Equitable cost allocation is defined as the "apportionment of cleanup expense among involved parties according to the impact their wastes have on total cleanup cost. Considerations for the model include: prior cleanup cost allocation efforts; existing hazard ranking systems; available cleanup cost information for on-site and off-site disposal and treatment ; and cleanup methodology requirements."

The model apportions cleanup costs by weighting factors given to individual wastes. These factors are: 1) waste quantity; 2) biological (toxic) factors; and 3) physical factors. The cleanup cost allocation factor for each PRP is the sum of its individual waste cleanup cost allocation factors.³³

The RCES was a project sponsored by the Office of Comptroller and the Office of Emergency and Remedial Response of EPA in 1983. The system's approach to estimating costs relies upon gathering a relatively small number of attributes that drive major remedial costs and by developing cost functions that could be used repetitively. A three step process was used:

1. Data concerning the problems at a site were collected.
2. Remedial actions likely to be taken were identified.
3. Cost estimates were developed for each remedial action using functions that incorporate the primary cost drivers.

Basically, a decision criteria was developed and applied to each site to determine the types of remedial actions that would be needed. Then, cost functions were used to generate estimates based on the remedial actions required. However, the accuracy of this method has never been tested.³⁴

³³ Adams, Richard, et al., "Cleanup Cost Allocation Model," *Cost and Economics, Hazardous materials Control Research Institute*, Silver Spring, MD, pp. 54-57.

³⁴ Wise, Kenneth, and Amman, Paul, "Remedial Cost Estimation System for Superfund Sites," *Cost and Economics, Hazardous Materials Control Research Institute*, Silver Spring, MD, pp.58-62.

APPENDIX C TO CHAPTER 10

Summaries of Computerized ER Cost Estimating Tools

On the following pages are individual summaries of computerized ER cost estimating tools. A short narrative is provided for each tool along with form(s) detailing the specific attributes of the system.

Summary Sheet
Cost of Remedial Action (CORA) Model

CORA or the Cost of Remedial Action was developed by the firm of CH₂M Hill to estimate the RD/RA costs involved in a Superfund site cleanup. The development of the tool was funded by the EPA and is currently being refined through experimental use and validation. The validation of the tool was conducted by ICF Inc. ICF found CORA to be useful in predicting remedies at groups of sites. According to the study CORA performed within the acceptable range -40% to 60% in estimating overall budget costs for groups of sites

CORA can be run on a standard PC with MS-DOS, a 5 megabyte hard disk, and 640K RAM. The tool was initiated in 1986 for the purpose of site-specific budgeting of outyear Superfund remedial actions. Phase I model (Version 1.0) has been developed and validated. Phase II model (Version 2.1) has been developed, refined and released. CORA's main limitation for DOE users is that it does not address radioactive waste sites.

The model is designed for use by EPA regional site project officers familiar with a site. For this reason, users should have some technical understanding of the remediation process and a good familiarity with the site to be costed. Also, users should have technical site information accessible when running the model. RI level data is particularly useful.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Environmental Protection Agency

Name of Tool: Cost of Remedial Action (CORA)

1. **Name of Vendor:** CH₂M Hill
P.O. Box 4400
Reston, VA 22090
(703) 471-1441 Attn: Ms. Jacque Crenca
2. **Contact Person:** Mr. Kirby Biggs, U.S. EPA
3. **Telephone Number:** (202) 475-9756
4. **Complete Address:** U.S. EPA
Hazardous Site Control Division
Washington, DC 20460
5. **Description of Tool:** CORA is a menu driven system that contains two component systems. An expert system allows the user chose the appropriate remedial technology. The unit cost data base enables the user to cost out the site based on the remedial technology chosen.
6. **Programming Language:** Level 5 Expert System shell version 1.0
7. **Operating System:** MS-DOS
8. **Hardware Requirements:** Standard IBM PC with 640K RAM, 5 megabytes of hard disk space.
9. **Is Special Training Required? (If yes, Please Explain):** No, the program basically walks the user through the steps and a useable manual is included with the system.
10. **How Long Has The Tool Been Used:** Approximately 3 years.
11. **For What Purpose(s):** RD/RA cost estimates and remedial technology selection.
12. **What Are The Limitations of The Tool:** CORA does not contain modules for radioactive, mixed waste or waste ordinance sites.
13. **Have You or Others Validated the Tool:** ICF Inc. validated the tool based on 12 sites. They found the tool to have an accuracy range of plus 60% to minus 40%. This is broader than the plus 50% to minus 30% range generally associated with order-of-magnitude estimates.

Summary Sheet

COSTPRO

COSTPRO is a generic cost estimating system that can be used to prepare cost estimates on projects from the planning stage through detailed design. The code is a complete commercial rewrite of the Los Alamos National Laboratory's mainframe cost estimating system and, by virtue of its origin, is particularly well adapted to preparing estimates for DOE projects. One of the strengths of the system is its ability to manage up to four different work breakdown structures simultaneously without re-entering the basic cost estimate takeoff data. This is particularly helpful in instances where multiple format reporting may be required or where reporting requirements are not known in advance or can be expected to change over the life of the project.

QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS

Name of Sponsoring Organization/Client: Commercial

Name of Tool: COSTPRO

1. Name of Vendor: Inpro Inc.
1613 University Blvd. NE
Albuquerque, NM 87106
2. Contact Person: Dr. Alan Dudley
3. Telephone Number: (505) 243-2800
4. Complete Address: Same as Inpro
5. Description of Tool: COSTPRO is a generic cost estimating analysis and reporting tool which prepares cost estimates in many different styles through a flexible series of report development menus. Extensive capability is available to apply markups for indirect costs, job conditions, productivity, and taxes. The system can be used to estimate all cost elements (assessment, design, remediation) of a project and can be used to combine inputs from other models such as FAST. COSTPRO allows the user to build custom databases of their own or to import databases developed by others (such as CACES). The developer will work with customers to modify the model to meet the customized requirements.
6. Programming Language: FORTRAN, C-Language
7. Operating System: MS-DOS or PC-DOS
8. Hardware Requirements: Standard IBM-AT compatible or 386 with math coprocessor.
9. Is Special Training Required? (If yes, Please Explain): No. A detailed user manual is provided which instructs users in model operations.
10. How Long Has The Tool Been Used: The original code was written for the minicomputer and operated successfully in the early 1980s. The PC version became available in 1986 and has been in continual use ever since.
11. For What Purpose(s): COSTPRO has been used to prepare cost estimates on projects ranging in cost from \$10,000 to over \$500 million. Project types have ranged from new construction to environmental restoration related projects such as mixed waste disposal facilities and waste treatment processes.
12. What Are The Limitations of The Tool: As a consequence of the model's flexible format, the users ability is the principle limitation.
13. Have You or Others Validated the Tool: The accuracy of COSTPRO's estimates has been validated by Los Alamos National Laboratory.

Summary Sheet

Freiman Analysis of Systems Techniques (FAST) Models

The FAST (Freiman Analysis of Systems Techniques) models are a set of parametric cost estimating tools oriented towards order-of-magnitude estimating.³⁵ The models provide a framework for assessing costs when there is limited project design information and few precedents. The models facilitate customizing existing historical data to differing clean-up requirements through the linearly adjustable values that represent scope, clean-up method/activity and productivity. They also permit rapid calculation of "what-if" studies for varying quantities, qa/qc requirements, economics, schedules, and/or economies-of-scale. There are six FAST models (Equipment, Construction, Funding, Mining, Productivity, and Cost of Ownership). For environmental restoration projects, the equipment model (FAST-E) the construction model (FAST-C), and the cost-of-ownership (FAST-CO) are the most appropriate.

³⁵ A more detailed discussion of the FAST models can be found in Lesley A. Gasperow, John W. Hackney, and Kay K. Hudson, *Parametric Cost Estimating: A Guide*, Prepared for U.S. Department of Energy, Assistant Secretary of Defense Programs, Office of Project Management, August 1987.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Department of Energy

Name of Tool: Freiman Analysis of Systems Techniques (FAST) Models

1. **Name of Vendor:** FPS, Inc
2. **Contact Person:** Ms. Kay Hudson, U.S. DOE
3. **Telephone Number:** (301) 353-3181
4. **Complete Address:** Kay Hudson
Planning & Project Management Division
DP-521
U.S. Department of Energy
Washington, DC 20545
5. **Description of Tool:** FAST-Equipment, FAST-Construction, FAST-Cost-of-Ownership are parametric models that require calibration by the user to the user's estimating problem. Requires as little as one data point.
6. **Programming Language:** NA
7. **Operating System:** For FAST-E Dos 2.5 or higher.
8. **Hardware Requirements:** IBM compatible PC for FAST-E. IBM 386 or more recent version is recommended. FAST-C and FAST-CO are accessible via telephone line.
9. **Is Special Training Required? (If yes, Please Explain):** One week class per model.
10. **How Long Has The Tool Been Used:** See below.
11. **For What Purpose(s):** See below.
12. **What Are The Limitations of The Tool:** Requires calibration by user of at least one set of data from a historical (or estimated) project. The minimum set of data includes cost, year of economics, size (expressed in weight, area, volume or performance as appropriate), quantity, conditions and knowledge of conditions affecting the cost such as scope, productivity, levels cleaned to, etc.
13. **Have You or Others Validated the Tool:** The FAST-E model or its predecessor has been in use for non-ER estimating since the early 1970's. ER applications that have been made are few and recent. However, the results are realistic. The FAST-C and FAST-CO models have been in use for non-ER estimating since the early to mid 1980's. ER applications are modest in number but the results are realistic.

Summary Sheet

G2 Estimator

G2 Estimator was developed by G2, Inc., as a cost estimating system that provides the user with great flexibility to tailor the work environment as needed. The software comes with default values and work codes already defined but can be re-defined if desired. Data can be input in almost in manner using worksheets. Estimators use a cloning tool to pick up information from other estimates or from other parts of the current estimate. Cloning can also be used to adapt and upgrade the original bid estimate for different phases of the project, all the way through the operations and maintenance phase. Another tool, mergers, lets the lead estimator divide an estimate into any number of smaller sections, distribute the work, and then recompile the pieces, with any conflicts identified.³⁶

The National Construction Estimator is the standard database provided with the system. However, other commercial databases are provided as an option. Along with estimated cost and resources summaries, reports can include bar charts, graphs, and tables and can provide a time-phased project model.

³⁶ "Estimator Respects Quirks of Individuals," *ENR*, January 12, 1989, p. 24.

QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS

Name of Sponsoring Organization/Client: Commercial

Name of Tool: G2 Estimator

1. Name of Vendor: G2 Inc.
P.O. Box 7867
Boise, ID 83707-9892
(208) 344-5412
2. Contact Person: Michael Starace Jr.
3. Telephone Number: (208) 344-5412
4. Complete Address: Same as above
5. Description of Tool: A generic cost estimating tool that allows the user to tailor the estimate as needed.
6. Programming Language: NA
7. Operating System: MS-DOS 3.3 or greater.
8. Hardware Requirements: Standard IBM and compatible, 640K RAM, 286 microprocessor, hard drive.
9. Is Special Training Required? (If yes, Please Explain): No.
10. How Long Has The Tool Been Used: Approximately a year.
11. For What Purpose(s): Construction cost estimating.
12. What Are The Limitations of The Tool: NA
13. Have You or Others Validated the Tool: NA

Summary Sheet

HAZRISK Model

Independent Project Analysis (IPA), Inc.'s, HAZRISK model is in the process of being developed. Its development is being sponsored by the U.S. Department of Energy and a consortium of private sector companies. IPA is building these tools based on a database of historical costs and schedule for completed remedial investigations and actions. IPA's database will include DOE, EPA Superfund, DOD, and private industry sites. The database will include completed cost and schedule information on approximately 150 projects.

IPA's approach involves the systematic linking of cost and schedule outcomes (cost growth and schedule slip) with project characteristics such as the nature of the site, the contaminant(s) involved, the technologies selected, the characteristics of the federal, state, and local regulatory regimes, etc.. The links are forged using parametric statistical techniques such as correlation and simple and multiple regression. These techniques are powerful extensions of the plots and cost-capacity curves familiar to all cost engineers.

The HAZRISK model will run on any standard IBM compatible PC. The model will be able to be used in a variety of software packages such as Lotus 1-2-3, dBase III, and Paradox.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Department of Energy and Private Industry

Name of Tool: HAZRISK Model

1. **Name of Vendor:** Independent Project Analysis, Inc.
9409 Lagovista Court
Great Falls, VA 22066
(703) 759-0077 Attn: Edward Merrow
2. **Contact Person:** Kay Hudson, U.S. DOE
3. **Telephone Number:** (301) 353-3181
4. **Complete Address:** Kay Hudson
Project Management Division DP-533
U.S. Department of Energy
Washington, DC 20545
5. **Description of Tool:** The HAZRISK models will assist estimators in building order-of-magnitude cost estimates and cost contingency estimates for the remedial investigation/feasibility stage and the remedial design/remedial action stage of an environmental restoration project. Models for estimating the length of these two stages will also be available.
6. **Programming Language:** Lotus 1-2-3, dBase III, Paradox, and other software packages.
7. **Operating System:** MS-DOS
8. **Hardware Requirements:** Standard IBM PC XT/AT/PS 2
9. **Is Special Training Required? (If yes, Please Explain):** Some. Basic knowledge of statistics is required in order to use models effectively.
10. **How Long Has The Tool Been Used:** Under development (available April 1990).
11. **For What Purpose(s):**
12. **What Are The Limitations of The Tool:** Projects lying outside the range of the projects in the historical database cannot be estimated.
13. **Have You or Others Validated the Tool:** Full validation of the tool will be performed by IPA at time of delivery to U.S. DOE.

Summary Sheet

Liner Location Risk and Cost Analysis (LLM) Model and RCRA Risk Cost Analysis (WET) Model

Both the LLM and WET are mainframe systems developed by ICF Inc. for EPA's Office of Solid Waste. They are primarily intended to be used as policy analysis tools in order to evaluate remedial technology scenarios under different circumstances. The models serve as a way of discriminating cost differences between sites and gauging policy responses.

The LLM is applicable to land disposal sites (i.e., landfills and surface impoundments) and estimates the health risks and costs associated with various corrective actions and location scenarios. The LLM contains a cost sub-model that estimates cleanup costs based on liner design and size, remedial technology, plume size, and clean-up targets. The model requires that the user input a number of variables for each model run. These include chemical or waste identity and disposal quantity, facility design type and size, climate, groundwater flow, distance from facility to exposure point, and exposed population size. The system contains unit cost data and estimates costs based on a set of algorithms.

The WET model is used for evaluating the health risks and costs associated with different waste management technologies at RCRA sites. The model is designed so that it can be structured or altered to incorporate regulatory specifications. Thus, the different effects of alternative specifications can be identified. Default values and parameters can be changed for sensitivity analyses. The model consists of an array of possible ways to treat, store, and dispose of hazardous wastes. These possible waste management practices are formulated by combining three factors: 1) waste stream, 2) technologies to treat, transport, and dispose of the wastes, and 3) the environmental setting in which the wastes are managed. The model then calculates the health risks and costs associated with each waste management practice.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Environmental Protection Agency

Name of Tool: Liner Location Risk and Cost Analysis Model (LLM)

1. Name of Vendor: ICF, Inc. (contact: Joanne Colt)
9300 Lee Highway
Fairfax, VA 22031
(703) 934-3000

2. Contact Person: Ron Burke, U.S. Environmental Protection Agency

3. Telephone Number: (202) 382-2791

4. Complete Address: U.S. EPA
Office of Solid Waste
Washington, DC 20460

5. Description of Tool: A mainframe system for examining health risks and costs at land disposal sites and policy implications.

6. Programming Language:

7. Operating System:

8. Hardware Requirements: Mainframe

9. Is Special Training Required? (If yes, Please Explain): Not a user friendly system. Extensive training required.

10. How Long Has The Tool Been Used: Since 1983.

11. For What Purpose(s): Health risks and cost estimates at land disposal sites.

12. What Are The Limitations of The Tool:

13. Have You or Others Validated the Tool: No

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Environmental Protection Agency

Name of Tool: RCRA Risk-Cost Analysis Model (WET)

1. **Name of Vendor:** ICF, Inc. (contact: Jean Tilly)
9300 Lee Highway
Fairfax, VA 22031
(703) 934-3000

2. **Contact Person:** Ron Burke EPA

3. **Telephone Number:** (202) 382-2791

4. **Complete Address:** U.S. EPA
Office of Solid Waste
Washington, DC 20460

5. **Description of Tool:** A mainframe system for examining health risks and costs at waste management facilities.

6. **Programming Language:**

7. **Operating System:**

8. **Hardware Requirements:** Mainframe

9. **Is Special Training Required? (If yes, Please Explain):** Not a user friendly system. Extensive training required.

10. **How Long Has The Tool Been Used:** Since 1983.

11. **For What Purpose(s):** Health risks and cost estimates at land disposal sites.

12. **What Are The Limitations of The Tool:**

13. **Have You or Others Validated the Tool:** No

Summary Sheet

Micro-Computer Aided Cost Engineering Support System (M-CACES)

Micro-CACES was developed by the U.S. Army Corps of Engineers in 1987 as a micro-computer version of CACES. M-CACES is a detailed "bottoms-up" construction cost-estimating tool typically applied to heavy civil projects, new building construction, process plants, and rehabilitation projects. CACES is oriented towards lump-sum contracts. The Corps is in the process of building a environmental restoration unit cost library so that both the mainframe and micro version of CACES can be used for hazardous waste cleanup projects.

The primary purpose of the system is to prepare detailed cost estimates for building construction and related sitework. Currently, the database (CACES Unit Price Book) is being expanded to include heavy civil works line items and software modified to better handle heavy construction projects. The system has been applied to process plants. The Job Order Contracting (JOC) system is an adaptation of the original CACES and the Unit Price Book is used for operation and maintenance contracts at Army installations.

The CACES system provides standardized formats, in-depth cost analysis through detailed summaries, rapid execution of changes and data manipulation, electronic transmission of estimates, historical means to monitor cost changes, timesaving, management vehicle to control Architect-Engineer support, and expedient and accurate cost estimating techniques.³⁷

In addition, even though M-CACES is a "bottoms-up" detailed construction cost estimating tool, the Corps is presently adapting the Control Estimate Generator (CEG) from the mainframe computer to the microcomputer environment. The CEG is a budgetary estimating tool which uses 44 building models and sitework assemblies to replicate a detailed quantity takeoff which can be processed through the existing M-CACES estimating system to provide a detailed construction cost estimate at incomplete design stages.

³⁷ U.S. Army Corps of Engineers, Office of the Chief of Engineers, *Computer Aided Cost Engineering Support System: Description and Overview*, May 1, 1989.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Army Corps of Engineers

Name of Tool: Micro- Computer Aided Cost Engineering Support System (M-CACES)

1. **Name of Vendor:** Building Systems Design, Inc.
One Georgia Center
Suite 1440, 600 West Peachtree St.
Atlanta, GA 30308
President: John Witherspoon
(404) 876-4700
2. **Contact Person(s):** Larry Werner
Jim Nichols
Tommy Hunt
Jerrell Pennington
3. **Telephone Number:** (205) 895-5425
4. **Complete Address:** Same as above
5. **Description of Tool:** A system for detailed "bottoms-up" estimating at various construction projects. A unit cost library for environmental restoration projects. The system is currently being enhanced to support development of building cost estimates during incomplete design phases.
6. **Programming Language:** Microsoft "C" and Clipper
7. **Operating System:** MS-DOS
8. **Hardware Requirements:** Minimum suggested hardware is a 286 level IBM compatible microcomputer with a minimum of 20 megabytes of hard disk and 640k RAM. It is recommended that the printer output device be a laser printer.
9. **Is Special Training Required? (If yes, Please Explain):** Yes. Special courses on using M-CACES are offered by the Corps and Building Systems Design, Inc..
10. **How Long Has The Tool Been Used:** In the original version of the microcomputer software, the system has been available approximately 2 years.
11. **For What Purpose(s):** Construction Cost estimating.
12. **What Are The Limitations of The Tool:** M-CACES was developed primarily as a detailed building construction cost estimating system. Future releases will incorporate heavy construction and environmental restoration line items in the Unit Price Book and expand the software into cost estimating with less than complete design.
13. **Have You or Others Validated the Tool:** M-CACES has been validated internally by the Corps of Engineers.

Summary Sheet

Precision Estimating Plus

Precision Estimating Plus was developed by Timberline Software Corp., and combines the features of an electronic spreadsheet with an estimating system. It uses point-and-press windowing to allow the estimator to: (1) create and/or select items, phases and crews; (2) show item details and totals; and (3) perform work package take-off. A range of databases is available with the software to meet the specific needs of the estimator. The package interfaces with a variety of digitizers, has an expanded audit trail with dimensional take-off information and includes a custom report writer. The program has the capability to interface with developer's other project and accounting software.

QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS

Name of Sponsoring Organization/Client: Commercial

Name of Tool: Precision Estimating Plus

1. **Name of Vendor:** Timberline Software Corp.
9405 S W Gemini
Beaverton, OR 97005
(503) 626-6775
2. **Contact Person:** John Geffel
3. **Telephone Number:** (503) 626-6775
4. **Complete Address:** Same as above.
5. **Description of Tool:** Generic cost-estimating tool.
6. **Programming Language:** C
7. **Operating System:** MS-DOS or PC-DOS.
8. **Hardware Requirements:** Standard IBM XT, AT or PS/2, 512K RAM.
9. **Is Special Training Required? (If yes, Please Explain):** No, a training manual included with software.
However, special training is available by the developer.
10. **How Long Has The Tool Been Used:** Approx. 2 years.
11. **For What Purpose(s):** Construction cost estimating.
12. **What Are The Limitations of The Tool:** NA
13. **Have You or Others Validated the Tool:** NA

Summary Sheet

Remedial Response Construction Cost Estimating System (PRACES)

PRACES was developed by PEI for the EPA, Risk Reduction Engineering Laboratory. The system is structured to cost out remedial technologies and actions at a site and can generate detailed (line-item) capital and operations and maintenance costs, and present worth analysis. The system relies upon unit cost, cost estimating relationship (CER), and operations and maintenance cost databases. The tool requires that the user have some detailed design/site data however, most modules include default values for various parameters so that even when design data are not available, users may still generate budget or "ballpark" estimates. The system includes provisions to input numerous direct and indirect cost factors that adjust costs, accounting for such items as geographical location, health and safety, contingency, contractor overhead, etc. Use of this tool will probably be most accurate at the later stages of estimating a project such as the design stage when detailed data would be available.

The program is designed to be transportable and operate on an IBM PC/XT, AT, PS/2 or equivalent with at least 2 megabytes of available hard disk storage capacity and 640K RAM. The operating system must be MS-DOS 2.0 or higher. The program is written in Lahey Fortran. Lotus 1-2-3 spreadsheet software is an option to enable users to change values on intermediate output. The database is structured using dBASE III but is not required to operate the program.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: Environmental Protection Agency

Name of Tool: Remedial Response Construction Cost Estimating System (PRACES)

1. **Name of Vendor:** PEI Associates, Inc.
Chester Towers
Cincinnati, OH 45246
(513) 782-4700
Contact: Mr. John Abraham
2. **Contact Person:** Haynes Goddard
3. **Telephone Number:** (513) 569-7685
4. **Complete Address:** Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
26 W. Martin Luther King Drive
Cincinnati, OH 45268
5. **Description of Tool:** PRACES is a menu driven system that allows the user to model costs at a component level. The system is structured to cost out remedial technologies and actions at a site on a line-item approach from a unit cost, cost estimating relationship, and operations and maintenance item databases.
6. **Programming Language:** Lahey Fortran
7. **Operating System:** MS-DOS
8. **Hardware Requirements:** Standard IBM XT, AT or PS/2 with 640K RAM, 2 megabytes of hard disk space.
9. **Is Special Training Required? (If yes, Please Explain):** No, The program basically walks the user through the steps and a user manual is included with the system.
10. **How Long Has The Tool Been Used:** Approx. 2 years.
11. **For What Purpose(s):** RD/RA cost estimates and remedial technology.
12. **What Are The Limitations of The Tool:** More applicable at the design stage or later for budget or definitive estimates when detailed data is available. Can be used at preliminary stages through use of module default values and/or user's assumptions.
13. **Have You or Others Validated the Tool:** No

Summary Sheet

Remedial Action Assessment System (RAAS)

RAAS is currently under development for DOE's Office of Environment, Safety, and Health, by Pacific Northwest Laboratory. RAAS is designed to be used during the RI/FS stage as a computer based advisory tool to screen and evaluate remedial action alternatives. RAAS will work in tandem with the Multimedia Environmental Pollutant Assessment System (MEPAS) in order to "focus on and prioritize the environmental issues at a waste unit."³⁸ It will be, in effect, a total screening advisory tool as it will have the capacity to identify health risks and environmental damage as well as recommend remedial alternatives and estimate the remediation costs associated with a site.

RAAS will consist of a database containing various treatment technologies. The system applies a set of rules and algorithms to the database in order to screen and link retrieval, separation, treatment, and disposal technologies into remedial alternatives. Costs will be calculated based on algorithms associated with each remedial technology.

³⁸ Gene Whelan and Kenneth Hartz, "A Brief Summarization of the Remedial Action Assessment System (RAAS)," Prepared for US Department of Energy, Office of Environment, Safety, and Health, February 5, 1989, p. 1.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Department of Energy

Name of Tool: Remedial Action Assessment System (RAAS)

1. **Name of Vendor:** Pacific Northwest Laboratories
2. **Contact Person:** Richard Daley, U.S. DOE
3. **Telephone Number:** (202) 586-7117
4. **Complete Address:** U.S. Department of Energy
Forrestal Bldg., EH-231
1000 Independence Ave. SW
Washington, DC 20585
5. **Description of Tool:** Comprehensive tool for determining the appropriate technology for a site. Integrates with the MEPAS health risk assessment model.
6. **Programming Language:** Golden Common LISP, C
7. **Operating System:** UNIX
8. **Hardware Requirements:** Sun Work Station
9. **Is Special Training Required? (If yes, Please Explain):** Yes, training program will be developed near completion of development of RAAS.
10. **How Long Has The Tool Been Used:** Under Development
11. **For What Purpose(s):** RD/RA Health Risk, Technology Selection and Cost
12. **What Are The Limitations of The Tool:** To be determined.
13. **Have You or Others Validated the Tool:** Not yet validated.

Summary Sheet

Removal Cost Management System (RCMS)

RCMS or the Removal Cost Management System was developed by Roy F. Weston, Inc., for EPA. RCMS was developed as a cost management tool for federal On-Scene Coordinators (OSCs). Its purpose is to allow a OSCs or project managers to effectively track costs on a real-time basis while on-site in order to minimize unnecessary expenditures. The user tracks costs by entering known data inputs. The system also has the facility to estimate future costs. This part of the system, however, is not very sophisticated and is still in the process of being developed. As a result, best use of this system is for tracking costs to ensure that resources are being used effectively. The system runs on a standard IBM PC and requires 640K RAM and 2 megabytes of storage.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Environmental Protection Agency

Name of Tool: Removal Cost Management System (RCMS)

1. **Name of Vendor:** Roy F. Weston (contact: Mr. Matt Zimkovich)
2. **Contact Person:** Bob Ciboultia, U.S. EPA
3. **Telephone Number:** (202) 321-6746
4. **Complete Address:** U.S. EPA
Emergency Response Division
Washington, DC 20460
5. **Description of Tool:** RCMS is a cost-tracking and a cost-control system for emergency removals where the user enters known data inputs.
6. **Programming Language:**
7. **Operating System:** MS-DOS
8. **Hardware Requirements:** Standard IBM PC with 640K RAM, 2 megabyte hard disk.
9. **Is Special Training Required? (If yes, Please Explain):** No
10. **How Long Has The Tool Been Used:** Approximately 2 years
11. **For What Purpose(s):** Cost tracking and cost control of removals at remedial action sites.
12. **What Are The Limitations of The Tool:** Not very effective at projecting costs.
13. **Have You or Others Validated the Tool:**

Summary Sheet

Superfund Cost Estimating Expert System (SCEES)

SCEES or the Superfund Cost Estimating Expert System was developed by the CDM company to estimate the RI/FS costs involved in a Superfund site cleanup. The development of the tool was funded by the EPA and is currently being refined through experimental use and validation. The validation of the tool is progressing, supervised by the firm of Booz, Allen & Hamilton.

SCEES can be run on a standard PC with MS-DOS and 1.2 megabytes of expandable memory. The tool was originally designed to estimate the RI/FS costs of Landfills and Groundwater contaminated sites. However, the EPA Regional Offices are asking for the development of additional modules to cover other types of cleanup efforts.

The tool has been in existence for about one year and seems to work reasonably well. Special training is not required to run the system but a thorough knowledge of hazardous waste cleanup and site specific knowledge is required.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsoring Organization/Client: U.S. Environmental Protection Agency

Name of Tool: SCEES (Superfund Cost Estimating Expert System)

1. **Name of Vendor:** CDM Federal Programs Corporation
13135 Lee Jackson Memorial Highway, Suite 200
Fairfax, VA 22033
(703) 968-0900
Attn: Ms. Nancy Ketterer
2. **Contact Person:** Mr. Paul Wilkins or Mr. Chad Littleton, U.S. EPA
3. **Telephone Number:** (202) 475-7294
4. **Complete Address:** Office of Program Management, Room 385SE
U.S. Environmental Protection Agency
Washington, DC 20460
5. **Description of Tool:** SCEES is similar to CH2M Hill's CORA model. Both use site specific data information to estimate costs. However, SCEES was developed to estimate the costs of the RI/FS not the RD/RA as the CORA model does.
6. **Programming Language:** NEXPERT
7. **Operating System:** MS-DOS
8. **Hardware Requirements:** Standard IBM-compatible PC with 1.2 megabytes of expandable memory. Hardware key is needed to run the system.
9. **Is Special Training Required? (If yes, Please Explain):** No, the program basically walks the user through the steps and a useable manual is included with the system.
10. **How Long Has The Tool Been Used:** Approximately six months
11. **For What Purpose(s):** RI/FS cost estimates
12. **What Are The Limitations of The Tool:** Tool was designed to estimate the costs of Landfill and Groundwater contaminated sites. Modules need to be developed for other types of sites.
13. **Have You or Others Validated the Tool:** Booz, Allen & Hamilton is currently working on the validation of the tool. Seven sites are being used for the validation study.

Summary Sheet

Project Tracking for Environmental Restoration (TRAC-ER)

TRAC-ER is currently under development for DOE's Albuquerque Operations Environmental Restoration Project Office. TRAC-ER has a demonstrated capability to produce definitive cost estimates and has been successfully implemented at four installations in the ER Program. Coupled to a project scheduling system, TRAC-ER allows for the development of baseline costs and schedules and allows the user to track cost/schedule performance in assessment and remediation activities. The roll-up capability allows for reporting at upper or project management levels. By tracking projects, the user is building historical data following the Cost Assessment Team WBS guidelines. This data can then be rolled back into the unit cost database for future estimates and comparisons.

TRAC-ER is in the working prototype stage and is available for test use at other installations. The system uses menu driven, commercially available PC software that has been adapted for use by DOE. This provides a low cost system that is easy to learn and straight forward to implement.

**QUESTIONNAIRE FOR COST ESTIMATING TECHNIQUES AND METHODS
RELATED TO ENVIRONMENTAL RESTORATION**

Name of Sponsor: U.S. Department of Energy, Albuquerque Operations Office

Name of Tool: Project Tracking for Environmental Restoration (TRAC-ER)

1. **Name of Vendor:** Los Alamos National Laboratory
ER Technical Support Office
P.O. Box 1663 MS K485
Los Alamos, NM 87545
(505) 667-2415
Contact: Dr. Kenneth H. Rea, Group Leader or
Marc Zocher, Staff Member
2. **Contact Person:** Richard Sena, Project Manager
3. **Telephone Number:** (505) 845-6200
4. **Complete Address:** U.S. Department of Energy
Energy and Special Programs Division
Environmental Restoration Project Office
P.O. Box 5400
Albuquerque, NM 87115
5. **Description of Tool:** TRAC-ER is a definitive cost/schedule model designed for developing initial bottoms-up estimates and baseline schedules for assessment and cleanup activities. The system is structured to cost out activities based on a task outline structure. (The generic RI/FS assessment model contains over 300 activities.)
6. **Programming Language:** Timeline (Symantec Corp.), Open Plan (Welcome Software), and Lotus 1-2-3 (Lotus Development Corp.)
7. **Operating System:** MS-DOS
8. **Hardware Requirements:** IBM AT or PS/2 286 or 386 class with 640K RAM, 4 megabytes of hard disk space.
9. **Is Special Training Required? (If yes, Please Explain):** Yes, the user should be familiar with project management theory and technique.
10. **How Long Has The Tool Been Used:** Approximately six months.
11. **For What Purpose(s):** RCRA and CERCLA costing and scheduling at the Mound, Pinellas, Kansas City, and Sandia Livermore sites.
12. **What Are The Limitations of The Tool:** In pilot study at the present time through the Albuquerque Operations Office. More applicable when detailed data is available.
13. **Have You or Others Validated the Tool:** No.

APPENDIX A ACRONYMS AND ABBREVIATIONS

A	AASHTO	American Association of State Highway and Transportation Officials
	ABS	acrylonitrile butadiene styrene
	AC	Alternating Current
	ACE	U.S. Army Corps of Engineers
	ADS	Activity Data Sheet
	AE	architect/engineer
	AEA	Atomic Energy Act of 1954 and its subsequent amendments
	AEC	Atomic Energy Commission
	AHERA	Asbestos Hazard Emergency Response Act-1986 Act requiring school districts to analyze asbestos problems
	ALO	Albuquerque Operations Office
	ALARA	As Low As Reasonably Achievable
	AMDAS	Airborne Mine Detection and Scanning
	ANL	Argonne National Laboratory
	ANL-E	Argonne National Laboratory-East (Chicago)
	ANL-W	Argonne National Laboratory-West (at INEL)
	ANS	American Nuclear Society
	ANSI	American National Standards Institute
	ARARs	Applicable or Relevant and Appropriate Requirements
	ARCS	Alternative Remedial Contracts Strategy-serves to decentralize Superfund; each region control assumes authority
	ARAR	Applicable or Relevant and Appropriate Requirements
	ASA	American Standards Association
	ASCE	American Society of Civil Engineers
	ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
	ASME	American Society of Mechanical Engineers
	ASTM	American Society for Testing Materials
	ATSDR	Agency for Toxic Substances and Disease Registry-an agency of the U.S. Public Health Service
	AWPA	American Wood Products Association
	AWWA	American Water Works Association
B	bbc	balanced biological communities
	BCL	Battelle Columbus Laboratories
	BDAT	Best Demonstrated Available Technology
	bdle	bundle
	bf	board foot
	bg	burial ground
	BIA	Bureau of Indian Affairs
	BLM	U.S. Bureau of Land Management
	BNL	Brookhaven National Laboratory
	Btu	British thermal unit
C	b & w	black & white
	C	thermal conductance
	C	one hundred
	CA	Corrective Action
	CA	Code of Accounts
	CAA	Clean Air Act and its numerous amendments

CACES	Corps of Engineers' Computer-Aided Cost Engineering System
CAD	Computer-Aided Design or Corrective Action Document
CADD	Computer-Aided Design & Drafting
CAE	Computer-Aided Engineering
CAG	Cancer Assessment Group-a segment of EPA responsible for assessment of carcinogenic potency of pollutants
CDC	Center for Disease Control
CDR	Conceptual Design Report
CEARP	Comprehensive Environmental Assessment and Response Program
CER	Cost Estimating Relationship
CERCLA	Comprehensive Environmental Response Compensation and Liability Act - Superfund
cf	cubic foot
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CH	Chicago Operations Office
CH	contact handled
CIF	Consolidated Incinerator Facility
clp	100 linear feet
cm	centimeter
CM	Corrective Measures
CMA	Corrective Measures Alternatives
CMD	Corrective Measures Design
CMI	Corrective Measures Implementation
CMS	RCRA Corrective Measures Study
COCA	Consent Order and Compliance Agreement
CORA	Cost of Remedial Action
CPAF	Cost Plus Award Fee (Contract)
cpe	chlorinated polyethylene
CPFF	Cost Plus Fixed Fee (Contract)
CPM	counts per minute
cpvc	Chlorinated PolyVinyl Chloride
CRP	Community Relations Plan
csf	100 square feet
CSI	Construction Specifications Institute
CWA	Clean Water Act of 1982
cy	cubic yard

D	d	penny
	D	depth
	D&D	Decontamination and Decommissioning
	DBS	Debris Barrier System
	DC	Direct Current
	DFDP	Defense Facility Decommissioning Program
	dia	diameter
	DPP/CP	Detailed Project Planning/Concept Development
	DOD	Department of Defense
	DOD/DNA	U.S. Department of Defense/Defense Nuclear Agency
	DOE	U.S. Department of Energy
	DOJ	Department of Justice
	DOT	Department of Transportation
	DSB	double strength B quality glass
	dst	double-shell tank
	DWEL	Drinking Water Equivalent Level

	DWMP	Defense Waste Management Plan
	DWPF	Defense Waste Processing Facility
	dww	drain, waste, vent piping
E	E-MAD	Engine Maintenance Assembly and Disassembly
	EA	Environmental Assessment
	ea	Each
	EIS	Environmental Impact Statement
	EM	Environmental Restoration and Waste Management
	EM-CAT	Environmental Restoration and Waste Management Cost Assessment Team
	EMT	electric metallic tube
	EOD	Explosives Ordnance Disposal
	EPA	U.S. Environmental Protection Agency
	EPDM	ethylene propylene diene monomer
	ER	Exposure Rate or Environmental Restoration
	ER	Energy Research
	ERDA	Energy Research and Development Administration
	exp.	exposure
F	FA	Facilities Assessment
	FAA	Federal Aviation Administration
	FAST	Freiman Analysis of Systems Techniques
	FCDNA	Field Command Defense Nuclear Agency
	FFAs	Federal Facility Agreements
	FFCA	Federal Facility Compliance Agreement
	FI	Facilities Investigation
	FICA	Federal Insurance Contributions Act (social security tax)
	FI/CMS	Facilities Investigation/Corrective Measures Study
	FMPC	Feeds Materials Production Center (Fernald)
	fob	free on board
	fpm	feet per minute
	FPR	Federal Procurement Regulations
	FRD	Formerly Restricted Data
	frp	fiberglass reinforced plastic
	FS	Feasibility Study
	FS	Federal Specification
	FSAR	Final Safety Analysis Report
	FUCA	Federal Unemployment Compensation Act Tax
	FUSRAP	Formerly Utilized Sites Remedial Action Program
	FY	Fiscal Year
G	gal	gallon
	GAO	General Accounting Office
	gfi	ground fault circuit interrupter
	GFI	Ground Fault Interrupter
	GJPO	Grand Junction Project Office (Grand Junction)
	GOSIP	Government Open Systems Interconnection Profile
	gph	gallons per hour
	gpm	gallon(s) per minute
	GPP	General Plant Projects
	GSA	General Services Administration
	GTCC	Greater-Than-Class-C

H	h	height
	HA	Health Advisories-substitute standards for drinking water when no MCL or MCLG is available
	HAP	Hazardous Air Pollutants
	HAZMAT	Hazardous Materials
	HAZRISK	Hazardous Waste Cost Risk and Estimating Model
	HE	High Explosive
	HEPA	high-efficiency particulate air (filters)
	HLW	high-level waste
	HLLW	high-level liquid waste
	HMTA	Hazardous Materials Transportation Act
	hp	horsepower
	hr	hour
	HRS	Hazardous Ranking System-HRS is used for a number of environmental decisions, including ranking disposal sites for cleanup
	HSWA	Hazardous and Solid Waste Amendments of 1984-HSWA (pronounced hazwa)
	HVAC	heating, venting, and air conditioning
	HWVP	Hanford Waste Vitrification Plant
I	IAG	Interagency Agreement
	ICE	Independent Cost Estimate
	ICPP	Idaho Chemical Processing Plant
	IDO	Idaho Operations Office
	IDB	Integrated Data Base
	I&E	Inspection & Evaluation
	id	inside diameter
	imc	intermediate metal conduit
	INEL	Idaho National Engineering Laboratory
	ISV	In Situ Vitrification
K	ITRI	Inhalation Toxicology Research Institute (Albuquerque)
	KCP	Kansas City Plant
	kd	kiln dried or knocked down
	KSI	kips per square inch
	kV	kilo volt(s)
	kVA	1000 volt amps
	kW	kilowatts
L	kWH	kilowatt hour
	l	length
	LANL	Los Alamos National Laboratory
	LBL	Lawrence Berkeley Laboratory
	ldr	land disposal restrictions
	LEHR	Laboratory for Energy-Related Health Research
	LLM	Linear Locater and Risk Model
	LLNL	Lawrence Livermore National Laboratory
	LLRWPA	Low-Level Radioactive Waste Policy Act of 1980, including the Low-Level Radioactive Waste Policy Amendments Act of 1985-LLRWPA amended AEA
	LLW	Low-Level Radioactive Waste
	LLWDDD	Low-Level Waste Disposal Development Demonstration
	lp	liquified propane
	LS	Lump-Sum (Contract)

M	M	one thousand
	MAD	Maintenance Assemble and Disassembly
	Mb	million bytes (characters)
	MBF	1000 board feet
	MBtu	thousand British thermal units
	M-CACES	Micro-Computer Aided Cost Engineering Support System
	MCL	Maximum Contaminant Level-legally enforceable standard for drinking water
	MCLG	Maximum Containment Level Goal-a concentration of pollutants in drinking water defined under SDWA
	MCM	1000 circular mils
	MDO	medium density overlaid
	mhr	man-hour
	mi	mile
	Mixed Waste	Contains both radiological and hazardous constituents
	mlf	1000 linear feet
	mm	millimeter(s)
	mo	month
	MOU	Memorandum of Understanding
	mph	miles per hour
	MRS	Monitored Retrievable Storage
	MSF	1000 square feet
	MTR	Materials Test Reactor
	MWMF	Mixed Waste Management Facility
N	NAAQS	National Ambient Air Quality Standards
	NAS	National Academy of Sciences
	NCP	National Contingency Plan
	NE	Nuclear Energy
	NEMA	National Electrical Manufacturers Association
	NEPA	National Environmental Policy Act of 1969
	NESHAP	National Emission Standards for Hazardous Air Pollutants-source standards promulgated in accordance with CAA
	NEST	Nuclear Emergency Search Team
	NMEID	New Mexico Environmental Improvement Division
	NMWQCCR	New Mexico Water Quality Control Commission Regulations
	NOEL	No Observable Effect Level-a toxicological term
	NOx	nitrogen oxides
	NPDES	National Pollutant Discharge Elimination System
	NPL	National Priorities List - a list of abandoned hazardous waste sites requiring cleanup
	NRC	Nuclear Regulatory Commission or National Response Center
	nrc	noise reduction coefficient
	NRDC	Natural Resource Defense Council
	NRDA	Nuclear Research and Development Area
	NTS	Nevada Test Site
	NVO	Nevada Operations Office
	NWPA	Nuclear Waste Policy Act of 1982-NWPA amended AEA
	NYSERDA	New York State Energy Research and Development Administration
O	oc	spacing from center to center
	OCRWM	Office of Civilian Radioactive Waste Management
	od	outside diameter
	OM	Operations and Maintenance (usually M&O)

	OMB	Office of Management and Budget
	ORO	Oak Ridge Operations Office
	ORGDP	Oak Ridge Gaseous Diffusion Plant
	ORNL	Oak Ridge National Laboratory
	OSHA	Occupational Safety and Health Administration
	OTA	Office of Technology Assessment
	OWP	Office of Weapons Production
P	PA/SI	Preliminary Assessment/Site Investigation - a CERCLA process, identifying releases needing further investigation
	PCBs	polychlorinated biphenyls
	PE	Project Engineer, Professional Engineer
	PGDP	Paducah Gaseous Diffusion Plant (Paducah)
	PORTS	Portsmouth Gaseous Diffusion Plant (Portsmouth)
	POTW	publicly owned treatment works
	PRAOM	Post Remedial Action Operations and Maintenance
	PREPP	Processing Experimental Pilot Plant
	PRP	Potentially Responsible Parties - a group identified under CERCLA
	PSD	Prevention of Significant Deterioration
	PSF	pounds per square foot
	psi	pounds per square inch
	PST	Pilot-Scale Testing
	PVC	polyvinyl chloride
Q	QA	Quality Assurance
	QC	Quality Control
R	R	thermal resistance
	RA	Remedial Action
	RAAS	Remedial Action Assessment System
	RAP	remedial action program
	rad	unit of absorbed radiation
	RAMS	Remote Area Monitoring System
	RCB	Retrieval Containment Building
	RCMS	Removal/Cost Management System
	RCRA	Resource Conservation and Recovery Act and its amendments, including the Solid Waste Disposal Amendments of 1983 and HSWA
	R&D	Research & Development
	RD/RA	Remedial Design/Remedial Action-design and implementation of chosen remedy
	Report 2010	A DOE plan on dealing with weapons facilities over the next 20 years. It includes a blueprint for remedial work
	RFA	RCRA Facility Assessment
	RFI	RCRA Facility Investigation (Remedial Facility Investigation)
	RFP	Rocky Flats Plant
	rh	remote handled
	RI	Remedial Investigation - a CERCLA process characterizing the nature, extent, and rate of contamination releases
	RI/FS	Remedial Investigation/Feasibility Studies
	r/l	random length(s)
	RLO	Richland Operations Office
	RLP	Radiation Leak Path

ROD	Record of Decision
ROSES	Recording of Oscilloscope Sealed Environmental System
rpm	revolutions per minute
RQ	Reportable Quantities - a CERCLA term
rs	range station
rsc	rigid steel conduit
RSTN	Regional Seismic Test Network
RTD	Resistance Temperature Device
R/W/L	random widths and lengths
RWMS	Radioactive Waste Management Site
RWQCB	Regional Water Quality Control Board

S	S&M	surveillance and maintenance
	sa	sack
	SAN	San Francisco Operations Office
	SANDS	Surveillance/Accident Nuclear Detection System
	SARA	Superfund Amendments and Reauthorization Act of 1986-strengthened the authorities under CERCLA for responding to hazardous waste sites and increased the size of the Fund
	SCEES	Superfund Cost Estimating Expert System
	SCTI	Sodium Components Test Installation
	sdr	size to diameter ratio
	SDWA	Safe Drinking Water Act
	sf	square foot
	SFMP	Surplus Facilities Management Program
	SI	Site Inspection-a CERCLA process
	SIP	State Implementation Plan-an action required under CAA
	SLAC	Stanford Linear Accelerator Center
	SNL	Sandia National Laboratories
	SNLA	Sandia National Laboratories, Albuquerque
	SNLL	Sandia National Laboratories, Livermore
	SPCC	Spill Prevention Control and Countermeasures
	sq	100 square feet
	SRO	Savannah River Operations Office
	SRS	Savannah River Site
	SSB	single strength B quality glass
	sst	single-shell tank
	STC	sound transmission class
	std	standard
	STGWG	State and Tribal Government Working Group
	Superfund	The fund set up by CERCLA for cleanup of abandoned hazardous waste sites; a colloquial term used to describe CERCLA
	SWAT	Solid Waste Assessment Test
	SWDA	Solid Waste Disposal Act
	SWMUs	Solid Waste Management Units
	SWSA	Solid Waste Storage Area
	syd	square yard

T	t	thick, ton
	TCC	Total Constituent Concentration
	TCE	trichloroethylene
	TCLP	Toxicity Characteristic Leaching Procedure
	TD	Technology Demonstration

	TRA	Test Reactor Area
	TRAC-ER	Project Tracing for Environmental Restoration Model
	TRU	transuranic(s)
	TSCA	Toxic Substances Control Act of 1976 and its subsequent amendments
	TSD	Treatment Storage Disposal-terms used to indicate coverage by RCRA of facilities managing hazardous waste
	TTO	Total Toxic Organics
	TTR	Tonopah Test Range
	TV	television
	TWF	Transuranic Waste Facility
	TWTSF	Transuranic Waste Treatment and Storage Facility
U	UBC	Uniform Building Code
	UGMC	Underground Monitor Control
	UL	Underwriter's Laboratory
	UMT	uranium mill tailings
	UMTRA	Uranium Mill Tailings Remedial Action (Project)
	UMTRAP	Uranium Mill Tailings Remedial Action Program
	UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978-UMTRCA amended AEA
	USDA	United States Department of Agriculture
	UST	underground storage tank
V	vlf	vertical linear foot
	VOCs	volatile organic compounds
W	w	width
	w/	with
	WACC	Waste Acceptance Criteria Committee
	WAG	waste area grouping
	WBS	Work Breakdown Structure
	WERF	Waste Experimental Reduction Facility
	WHPP	Waste Handling and Packaging Plant
	WIN	Waste Information Network
	WIPP	Waste Isolation Pilot Plant
	wk	week
	WMO	waste management operations
	WQA	Water Quality Act of 1987
	WRAP	Waste Receiving and Processing (Plant)
	WSMR	White Sands Missile Range
X	x	by (or times) (multiply)

APPENDIX B GLOSSARY

Action Plan. A plan describing the implementation of a specific cleanup action.

Active Production Facility. Any ongoing operation that manufactures, recycles, handles, stores, or transports hazardous materials or waste as a primary ingredient, product, or by-product of operations, or any location contaminated due to off-site migration of hazardous materials or wastes from such ongoing operations.

Active Waste Management Facility. Any ongoing operation or site whose primary purpose is to handle, exchange, transfer, store, treat, or dispose of hazardous materials or wastes, or any location contaminated due to off-site migration of hazardous constituents.

Activity Data Sheet. The activity data sheet (ADS) supports the Environmental Restoration Planning, Budgeting, and Control System and relates to the Program summary work breakdown structure (WBS) at a specified level. It is the basic building block for Program life-cycle planning. An assessment ADS and a cleanup ADS define a remediation project. Management activities that are not associated with a specific remediation project are specified on separate ADSs.

The ADS format includes, as a minimum, a description of the assessment, cleanup, or management activity along with the associated cost, schedule, technical performance, budget and reporting (B&R) codes, and other pertinent information.

As a planning document, ADSs collectively reflect Program life-cycle planning (cost, schedule, and technical performance). They form the basic building blocks for the annual Five-Year Plan.

As a budgeting document, ADSs collectively reflect the life-cycle funds requirements for the Program. Expended funds, prior-year funds, current-year funds, budget-year funds, and budget-year-plus-one through budget-year-plus-five funds, and the remaining years funds are shown.

As a baseline document, ADSs collectively reflect Program baseline in terms of cost, schedule, and technical performance for the approved Program and the life-cycle planning baseline for the overall Program (PMP).

Agency for Toxic Substances and Disease Registry (ATSDR). An agency of the U.S. Public Health Service

Alternative Remedial Contracts Strategy (ARCS). Serves to decentralize Superfund; each region control assumes authority.

Applicable or Relevant and Appropriate Requirement (ARAR). Requirements, including cleanup standards, standards of control, and other substantive environmental protection requirements and criteria for hazardous substances as specified under Federal and State law and regulations, that must be met when complying with the Comprehensive Environmental Response, Compensation, and Liability Act (from the Superfund Amendments and Reauthorization Act).

Appraisal. A documented review of a management and/or technical discipline within a program or project performed in accordance with written guidance and criteria to verify, by examination and evaluation of objective evidence, that applicable program/project elements have been developed, documented, and effectively implemented in accordance with specified requirements.

As Low As Reasonably Achievable (ALARA). A radiation protection principle applied to radiation exposures, with costs and benefits taken into account.

Asbestos Hazard Emergency Response Act (AHERA). 1986 Act requiring school districts to analyze asbestos problems.

Atomic Energy Act (AEA). The Act (1947, 1954) which placed production and control of nuclear materials within a civilian agency, originally the Atomic Energy Commission.

Audit. A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents and to determine the effectiveness of implementation. An audit should not be confused with surveillance or inspection activities performed for the sole purpose of process control or product acceptance.

Baseline. A quantitative definition of cost, schedule, and technical performance that serves as a base or standard for measurement and control during the performance of an effort; the established plan against which the status of resources and the effort of the overall program, field program(s), project(s) task(s), or subtask(s) are measured, assessed, and controlled. Once established, baselines are subject to change control discipline (modified).

Baseline (Configuration). A configuration document package that is fixed at a specific time during the life cycle of a system and defines a formal departure point for control of future changes in performance, design, production, construction, and related technical requirements.

Below Regulatory Concern. A definable amount of low-level waste that can be deregulated with minimal risk to the public.

Best Available Technology (BAT) or Best Demonstrated Available Technology (BDAT). Treatment technologies that have been shown through actual use to yield the greatest environmental benefits among competing technologies.

Buffer Zone. The smallest region beyond the disposal unit that is required as controlled space for monitoring and for taking mitigative measures, as may be required.

By-Product Rule (DOE). DOE rule making (Federal Register, May 1, 1987) that established Department policy for application of the Resource Conservation and Recovery Act and the Atomic Energy Act to Department of Energy waste containing hazardous components and by-product materials.

Calcining. The process of making unconsolidated powder of granules by thermal evaporation and partial decomposition (release of gases) of high-level waste.

Characterization. Site sampling, monitoring, and analysis activities to determine the extent and nature of the release. Characterization provides the basis for acquiring the necessary technical information to develop, screen, analyze, and select appropriate cleanup techniques.

Closure Plan. Documentation prepared to guide the deactivation, stabilization, and surveillance of a waste management unit or facility under the Resource Conservation and Recovery Act.

Compliance Agreements. Legally binding agreements between regulators and regulated entities that set standards and schedules for compliance with environmental statutes. Includes Consent Order and Compliance Agreements, Federal Facilities Agreements, and Federal Facilities Compliance Agreements.

Compliance or External Oversight: Effort that State is going to perform to assess the DOE's programs and will be funded by DOE.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Federal statute (also known as Superfund) enacted in 1980 and reauthorized in 1986, that provides the statutory authority for cleanup of hazardous substances that could endanger public health, welfare, or the environment.

Computerized Cost Estimating Tools. Either software package or computer based model used for cost estimating.

Consent Order and Compliance Agreement (COCA). See Compliance Agreements.

Contingency. The amount budgeted to cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties. The amount of the contingency will depend on the status of design, procurement, and construction and the complexity and uncertainty of the component parts of the project. Contingency is not to be used to avoid making an accurate assessment of expected cost.

Continuity of Operations. Each DOE site has activities that include developing strategic and long-range waste management plans, surveillance and maintenance of facilities and equipment, waste certification, proper training programs for personnel, and record/information administration.

Contractor. Includes all persons, organizations, departments, divisions, and companies having contracts, agreements, or memoranda of understanding with the Department of Energy (DOE).

Corrective Action. A measure taken to rectify conditions adverse to quality and, where necessary, to preclude repetition.

Decommissioning. The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

Decontamination. The removal of unwanted material (typically radioactive material) from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

Defense Waste. Radioactive waste from any activity performed in whole or in part in support of DOE atomic energy defense activities; excludes waste under purview of the Nuclear Regulatory Commission or generated by the commercial nuclear power industry.

Defense Waste Management Plan (DWMP). This Plan (June 1983) established the Department of Energy's policy for storage and disposal of its defense high-level and transuranic wastes.

Definitive Estimate. An estimate conducted during the latter stages of a project when engineering may be up to 40% completed. The actual cost should be within plus 15% to minus 5% of the estimate.

Demonstration. The verification of scale-up, economic, and environmental viability for commercial or developmental remedial action technology application through design, construction, testing, and evaluation of large-scale systems in operational circumstances.

Depleted Uranium. Uranium from which the fissionable isotope U-235 had been removed.

Detailed Methods. Tools which rely on unit cost databases for estimating costs.

Disposal. Waste emplacement designed to ensure isolation of waste from the biosphere, with no intention of retrieval for the foreseeable future, and that requires deliberate action to regain access to the waste.

Document. Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. A document is not considered to be a quality assurance record until it satisfies the definition of a quality assurance record.

DOE Orders. Internal requirements which establish DOE policy and procedures for compliance with applicable laws and regulations.

Drinking Water Standard. Concentration limits for certain elements and pollutants that may occur in drinking water; established by the Safe Drinking Water Act.

Environmental Restoration. Cleanup and restoration of sites contaminated with hazardous substances during past production or disposal activities.

Environmental Restoration Cost-Estimating Tools: Tools or models used explicitly for estimating costs for environmental restoration projects.

Facility. A building and its functional systems and equipment, process systems and associated piping, landfills, and impoundments. A facility is usually associated with a unique process or operation at a given location.

Feasibility Study. The objectives of the feasibility study are to identify the alternatives for remediation and to select and describe a remedial action that satisfies the applicable or relevant and appropriate requirements for mitigating confirmed environmental contamination. Successful completion of the feasibility study should result in unimpeded subsequent development of a remedial design for implementation of the selected remedial actions.

Federal Facilities Agreement (model FFA). See Compliance Agreements.

Federal Facilities Compliance Agreement. See Compliance Agreements.

Field Work Proposal. The field work proposal (FWP) is a document prepared by the Field Office that describes remediation work (assessment and cleanup) to be accomplished for a specified project or a group of projects at an installation. The FWP specifies the work necessary to comply with applicable regulatory requirements in terms of cost, schedule, and technical performance by fiscal years on a life-cycle basis. Also identified are the applicable ADSs. Programmatically, the FWP represents the level at which the Program is described and progress is reported by Headquarters, but FWPs are prepared by the responsible Field Offices. The ADS baselines comprising the FWPs are controlled by the responsible Field Officer; however, baseline control of the FWPs is maintained at Headquarters.

Forecast. The DOE project management office's most current performance projection for cost, schedule, and scope.

Formerly Utilized Sites Remedial Action Program (FUSRAP). A program that addresses the cleanup of sites and adjacent properties contaminated by activities of the Manhattan Project.

Friable Asbestos. Asbestos insulation that is loose and capable of becoming airborne.

Gaseous Diffusion. A technology for separating fissionable uranium-235 isotopes from the more abundant nonfissionable uranium isotopes by pumping gaseous uranium hexafluoride through resistant barriers.

Generic Cost-Estimating Tools. Tools or models that are typically used for estimating conventional construction costs. They also may have the capability of estimating costs for environmental restoration projects.

Geological Repository. A mined facility for disposal of radioactive wastes that provides a stable environment over geological time scales.

Greater-Than-Class-C waste. Waste that exceeds the Nuclear Regulatory Commission concentration limits for Class C low-level waste as specified in 10 CFR 61.

Groundwater Remediation. Treatment of groundwater to remove pollutants.

Hazardous and Solid Waste Amendments of 1984 (HSWA). HSWA (pronounced hazwa) amended RCRA, and greatly expanded US EPA's authority to require corrective actions.

Hazardous Ranking System (HRS). A U.S. EPA scoring system used for a number of environmental decisions, including ranking disposal sites for cleanup.

Hazardous Waste. As defined in the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, that because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

High-Level Waste. The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.

Inactive Waste Site. Sites formerly used for the treatment, storage, or disposal of wastes.

Incineration. A treatment technology using combustion to destroy organic constituents and reduce the volume of wastes.

Inspection. Examination or measurement to verify whether an item or activity conforms to specified requirements.

Interagency Agreement (IAG). A formal document in which two or more Federal agencies agree to cooperate.

Intermediate Estimate. An estimate conducted at the intermediate stages of a project or the beginning of the design stage. This estimate is sometimes referred to as budget estimate.

Item. An all-inclusive term used in place of any of the following: appurtenance, assembly, component, equipment, material, module, part, structure, facility, subassembly, system, subsystem, or unit.

Land Disposal Restrictions (LDRs). Provisions of Hazardous and Solid Waste Amendments requiring phased-in treatment of hazardous wastes before disposal.

Life-Cycle Program Planning. Life-cycle program planning represents the total planning necessary to achieve Program objectives. It involves the planning accomplished at Headquarters and the Field Offices to execute and control the program. The total life-cycle is represented by the composite of the life-cycles of the various remediation projects at the installations and Field Offices and management activities that are not applicable to a specific project. Effective planning and control are based on life-cycle events rather than arbitrary time spans having no natural relationship to completing the program. Life-cycle program planning is modified throughout the life of the program as better knowledge and experience are obtained.

Examples of life-cycle program planning with varying life-cycle lengths include the Weldon Springs Site Remedial Actions Project baselined to 1998, the Oak Ridge National Laboratory Remedial Investigation/Feasibility Study Project currently baseline to 2000, and the Formerly Utilized Sites Remedial Actions Program baselined to 2012.

Life-Cycle Project Planning. Life-cycle project planning is done within the context of the total life of a remediation project. The life-cycle commences with the inclusion of a remediation project into the On-Site Remediation Program and ends when the project no longer requires program resources. Life-cycle project planning involves specifying the remediation activities for the life of the project and not for an arbitrary time span that may be reflected by documents such as the Five-Year Plan or the three-year budget submittals.

Life-cycle project planning consists of the total effort necessary to ensure that a release site(s) is remediated and will remain in compliance. The project life-cycle, consisting of a potential, suspected, or actual release site(s), is accomplished over six phases. The first four phases consist of the assessment task, and the last two phases consist of the cleanup task.

Life-cycle project planning of assessment and cleanup activities ensures that necessary information is available for effective planning, execution, and control. Remediation ADSs for assessment and cleanup tasks reflect the totality of work planned to remediate a release site(s). Baseline information concerning cost, schedule, and technical performance is specified and controlled on a life-cycle basis.

Low-Level Radioactive Waste Policy Amendments Act of 1985. This Act makes the Federal Government responsible for disposing of greater-than-Class-C (higher-activity) low-level waste from commercial activities licensed by the Nuclear Regulatory Commission. Provisions of the Act name the Department of Energy as the Federal agency responsible for performing this function.

Low-Level Waste. Radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or by-product material.

Memorandum of Understanding. An agreement between the Environmental Protection Agency and another agency (federal, state, or local) that sets forth basic policies and procedures governing their relationship on matters of mutual interest and responsibility. There is no exchange of funds under this type of agreement.

Milestone. An important or critical event and/or activity that must occur in the project cycle to achieve the project's objective(s).

Mixed Waste. Mixed waste contains both radioactive and hazardous components, as defined by the Atomic Energy Act and the Resource Conservation and Recovery Act, respectively.

National Emission Standards for Hazardous Air Polluting Substances (NESHAPS). Clean Air Act limits for release of hazardous pollutants for which no ambient air quality standard is applicable.

National Environmental Policy Act (NEPA) of 1969. Act which established the requirement for conducting environmental reviews of Federal actions that have the potential for adverse impact on the human environment.

National Pollutant Discharge Elimination System (NPDES). Section 402 of the Federal Water Pollution Control Act (a.k.a. Clean Water Act) that establishes a permit for discharges to water and provides standards by which such permits may be granted.

National Priorities List. Formal listing of the nation's worst hazardous waste sites, as established by the Comprehensive Environmental Response, Compensation, and Liability Act.

Neutralization. Treatment of corrosive hazardous wastes to yield a pH near 7.

Nuclear Waste Fund. A fund established by the Nuclear Waste Policy Act of 1982, which directed DOE to pursue a policy toward disposal of commercial high-level and transuranic waste in a geological repository. The nuclear waste fund assesses utilities a fee to pay for siting, development, and operation of a commercial repository. The share of the costs commensurate with the portion of the repository committed for disposal of defense wastes will be paid by DOE.

On-Site. For permitting purposes, the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of all the response action.

Operable Unit: A discrete portion of a DOE installation identified as a group of release sites placed together for the purpose of remediation as a single project. Operable units (OUs) may represent geographical portions of an installation, or they may represent a specific installation problem such as surface/subsurface groundwater contamination. Cleanup of an installation may be divided into a number of OUs, depending on the complexity of the problems associated with the installation. An OU may represent all or part of discrete locations such as waste area groups (WAGs) and solid waste management units (SWMUs). OUs usually contains more than one release site, may be in close geographic proximity to other OUs, and may exhibit similar waste characteristics and types of releases. Release sites do not have to be contiguous to be included in a specific OU.

Operations and Maintenance (O&M). Activities required to maintain the effectiveness of response actions.

Operations Offices (U.S. DOE). Albuquerque, Chicago, Idaho, Nevada, Oak Ridge, Richland, San Francisco, and Savannah River.

Order-of Magnitude Estimate. An estimate conducted during the preliminary stages of a project.

Oversight. The program management role is exercised by the Headquarters On-Site Remediation Program Office over program planning, execution, and control by the Field Offices to ensure identified sites are remediated and maintained in compliance. Management oversight entails planning, programming, budgeting, and control of the program at the Headquarters level. Key characteristics include maintaining awareness of program activities, significant problems, and corrective actions at the Field Office level; approving key Field Office program documentation affecting quality; and ensuring Field Office management systems are adequate to meet program needs. Management oversight involves assurance type functional activities necessary to ensure that approved life-cycle baselines are effectively identified and controlled.

Parametric Approach. Tools which rely on the historical costs of previous remedial actions to build parametric cost estimating relationships. Often referred to as Cost-Estimating Relationships (CERs).

Planning Estimate. A cost estimate for general planning and budgeting purposes only. Planning estimates will be used when there is a need for an order-of-magnitude estimate, but sufficient definitive information is lacking that would allow the development of a total estimated cost. Planning estimates are developed for each project (program) at the time of project identification. Since these are developed before conceptual design, they are order of magnitude only and have the least amount of accuracy and lowest confidence level. Care should be exercised in these estimates to ensure that the order of magnitude is correct, since a tendency exists to avoid changing, particularly upward, this estimate once established.

Preliminary Assessment/Site Investigation (PA/SI). One of the first stages in remediating a site, the PA/SI is designed to evaluate all known information about the site and to conduct a preliminary investigation of the extent and nature of the contamination at the site. The purpose is to determine if further action or investigation is appropriate. Data collected during this period is used to build on HRS score for the site.

Prevention of Significant Deterioration (PSD). Part C of the Clean Air Act that establishes a policy of limiting degradation of air quality based upon classification of areas.

Prime Contractor. DOE's major contractors. Principally, DOE's management and operations contractors.

Procedure. A document that specifies or describes how an activity is to be performed.

Procurement Document. Purchase requisitions, purchase orders, drawings, contracts, contract task orders, specifications, or instructions used to determine requirements for purchase (modified).

Program. An organized set of activities directed toward a common purpose or goal undertaken or proposed in support of an assigned mission area. It is characterized by a strategy for accomplishing a definite objective(s) that identifies the means of accomplishment, particularly in qualitative terms with respect to work force, material, and facility requirements. Programs are typically made up of technology-based activities, projects, and supporting operations. For the purposes of this document, the term "Program" specifies the On-Site Remediation Program managed by the DOE Office of Environmental Restoration and Waste Management, a major program under the DOE Environmental Restoration Program.

Program Manager. An individual in an organization or activity who is responsible for the management of a specific function or functions, budget formulation, and execution of the approved budget. The Program Manager receives an approved funding program from responsible authority identifying program dollars available to accomplish the assigned function.

Program Objectives. A statement or set of statements defining the purposes and goals to be achieved during performance of a program to fulfill a DOE mission, including the technical capabilities, cost, and schedule goals.

Program Office. The Headquarters organizational element responsible for managing a program. For purposes of this document, the unique Program organizational elements responsible for managing assigned Program remediation activities at Headquarters, Field Offices, and Installations.

Program Participant. Any organization, contractor, or individual who is responsible for meeting assigned Program objectives.

Project. A unique major effort within a program that has firmly scheduled beginning, intermediate, and ending date milestones; prescribed performance requirements; prescribed costs; and close management, planning, and control. The project is the basic building block in relation to a program that is individually planned, approved, and managed. For purposes of this document, a project is a unique remediation effort established to meet Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), or RCRA/CERCLA statutory requirements applicable to an OU. It is specified at the third Project Summary WBS level (under Field Remediation, Level 1.1): Project (OU) Summary.

Quality. The totality of features and characteristics of an item or service that bears on its ability to satisfy given needs; fitness for intended use, which includes conformance to requirements (modified).

Quality Assurance. All those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily in service.

Quality Control. All those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements. Quality Control is the regulatory process through which we measure actual quality performance, compare it with standards, and act on the difference (modified).

RCRA Facility Assessment (RFA). The initial Resource Conservation and Recovery Act (RCRA) process to determine whether corrective action for a RCRA past practice unit is warranted or to define what additional data must be gathered to make this determination; analogous to a Comprehensive Environmental Response, Compensation, and Liability Act Preliminary Assessment and Site Inspection.

RCRA Facility Investigation (RFI). The RCRA process to determine the extent of hazardous waste contamination; analogous to the Comprehensive Environmental Response, Compensation, and Liability Act Remedial Investigation.

RCRA Part B Permit. The detailed second part of a Resource Conservation and Recovery Act permit application that describes wastes managed, quantities, and facilities.

Radioactive Waste. A solid, liquid, or gaseous material of negligible economic value that contains radionuclides in excess of threshold quantities except for radioactive material from post-weapons-test activities.

Record of Decision (ROD). A decision for an Environmental Protection Agency or state-led project that (1) documents decision making, (2) shows decision making consistency with CERCLA and the National Contingency Plan, and (3) supplements the feasibility study, if necessary. The record of decision is equivalent to the compliance agreement in a federal-agency-led project.

Regulated Substance. Any chemical, compound, or material the manufacture, generation, transportation, alteration, or disposition of which is regulated under any of the Federal or State statutes.

Release Site. As defined by Sect. 101(22) of CERCLA, as amended, a release is any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of [a hazardous substance] into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substances, pollutants, or contaminants), but excludes any release that results in exposure to persons solely within a work place, with respect to a claim that such persons may assert

against the employer of such persons; emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine; release of source, by-product, or special nuclear material from a nuclear incident, as those terms are defined in the Atomic Energy Act of 1954, if such release is subject to requirements with respect to financial protection established by the Nuclear Regulatory Commission under Sect. 170 of such Act or, for those purposes of Sect. 104 of CERCLA, as amended, or any other response action, any release of source, by-product, or special nuclear material from any processing site designated under Sect. 102(a)(1) or 302(a) of the Uranium Mill Tailings Radiation Control Act of 1978; and the normal application of fertilizer. A release site is a location at which a hazardous waste release has occurred or has the potential to occur (or is suspected to have occurred). It is usually associated with an area where hazardous substances have been treated, stored, and/or disposed of. A release site is the lowest element of an installation to be remediated.

Remedial Action. A subactivity (CERCLA term) in a remedial response involving actual implementation, following remedial design, of the selected source control and/or off-site remedial effort.

Remedial Investigation (RI). The Comprehensive Environmental Response, Compensation, and Liability Act process of determining the extent of hazardous substance contamination and, as appropriate, conducting treatability investigations. The RI is often done in conjunction with the Feasibility Study.

Research and Development (also called Development). The development and testing of systems and pilot plants judged to be technically and economically desirable as a means of achieving principal Environmental Restoration Program goals. Engineering development concerns itself with processes, preproduction components, equipment, subsystems, and systems. Initiation of work in this category is dependent upon successful demonstration of a technical feasibility and economic potential during the technology phase.

Risk. The combined effect of the probability and consequences of failure of an item expressed in qualitative or quantitative terms.

Risk/Health Assessment. The potential for realization of unwanted negative consequences or events. Public health risk assessment is a quantitative or qualitative evaluation of data from sources, such as toxicology and epidemiology, to predict the effects of public exposure to environmental factors that pose a potential hazard to the health and well-being of the public. Environmental and/or health effects resulting from exposure to a chemical or physical agent (pollutant) are combined with toxicity assessment results to provide an overall estimate or risk to the public. The process includes identification of the threat's source, determination of the threat's potential extent or magnitude, and resolution of probability that the defined undesirable situation will ensue from the exposure. *Risk estimate* is a description of the probability that organisms exposed to a specific dose of chemical will develop an adverse response (e.g., cancer).

Root Cause. The base condition, state, or definition of an item, system, or program element that brings about, or has a probability of bringing about, an effect that was not planned or desired.

Safe Drinking Water Act. The maximum contaminant levels developed under this Act are used in groundwater monitoring programs.

Sanitary Waste. Wastes, such as garbage, that are generated by normal housekeeping activities and that are not hazardous or radioactive.

Scope Change. A change in task objectives, plans (project or field work), or schedule that results in a material difference from the terms of an approval to proceed previously granted by higher authority. Under certain conditions, change in resource application may constitute a change in scope.

Shallow Land Burial. Disposal of wastes in shallow trenches; commonly used for low-level radioactive wastes.

Site. A geographic entity comprising land, buildings, and other facilities required to perform program objectives. Generally a site has, organizationally, all of the required facility management functions (i.e., it is not a satellite of some other site). For purposes of this document, site and installation are synonymous.

Site Inspection. The purpose of the site inspection is to acquire the necessary data to confirm the existence of environmental contamination at identified potential sites and to assess the associated potential risks to human health, welfare, and the environment. The data collected at each site must be sufficient to support the decision for either continuing with a remedial investigation/feasibility study or for removing the site from further investigation through a decision document.

Software. The programs, procedures, rules, and any associated documentation pertaining to the operation of a computer system

Sole-Source Aquifer. As defined by the Safe Drinking Water Act, an aquifer that is the only source or potential source of drinking water in an area.

Solid Waste Management Unit (SWMU). Any unit at a facility from which hazardous constituents might migrate, irrespective of whether the unit was intended for the management of solid and/or hazardous waste. Includes but is not limited to container storage areas, tanks, surface impoundments, waste piles, land treatment units, landfills, incinerators, injection wells, recycling operations, miscellaneous units, and release from such units.

Storage. Retention and monitoring of waste in a retrievable manner pending final disposal.

Superfund. The fund set up by CERCLA for cleanup of abandoned hazardous waste sites; a colloquial term used to describe CERCLA.

Superfund Amendments and Reauthorization Act (SARA). The 1987 Act amending and reauthorizing the Comprehensive Environmental Response, Compensation, and Liability Act.

Surplus Facility. Any facility or site (including equipment) that has no identified programmatic use.

Surveillance. The act of monitoring or observing to verify whether an item or activity conforms to specified requirements.

Task. A unique entity of work within the Environmental Restoration Program that addresses either the assessment effort or cleanup effort for remediating an OU. An assessment task can consist of up to four subtasks representing the first four remediation phases, usually accomplished in series. A cleanup task consists of two subtasks representing the remaining two remediation phases. The subtasks are the basic building blocks in the Program and, as such, are individually planned, approved, executed, and controlled. It is defined at the fourth WBS level: Remediation Task Summary.

Total Estimated Cost. An estimate of the total cost of a task, demonstration, or program. The total estimated cost differs from a planning estimate in that it is based on definitive information regarding technical scope, contracting methods, schedule, and resource requirements. As such, once a task is approved, its total estimated cost is baselined and becomes subject to change control procedures.

Toxic Substance Control Act. Requires the identification and control of toxic chemicals that pose a hazard to human health and the environment.

Traceability. The ability to trace the history, application, or location of an item and like items or activities by means of recorded identification.

Transuranic (TRU) Waste. Waste that is contaminated with alpha-emitting transuranium nuclides with half-lives greater than 20 years and concentrates greater than 100 nanocuries per gram of waste.

Treatment. Any activity that alters the chemical or physical nature of a waste to reduce its toxicity or prepare it for disposal.

Treatment Storage Disposal (TSD). Terms used to indicate coverage by RCRA of facilities managing hazardous waste.

Tri-Party Agreement. An agreement signed by Department of Energy, Environmental Protection Agency, and States that identified milestones for key waste management actions.

Underground Storage Tank (UST). Any tank or associated piping containing hazardous materials as defined by the Hazardous and Solid Waste Amendment.

Uranium Mill Tailings Radiation Control Act of 1978. This Act directed the Department of Energy (DOE) to provide for stabilization and control of the uranium mill tailings from inactive sites in a safe and environmentally sound manner to minimize radiation health hazards to the public. It authorized DOE to undertake remedial actions at 24 designated uranium processing sites at an estimated 5048 vicinity properties.

Vitrification. A method of immobilizing waste that produces a glass-like solid.

Waste Area Group (WAG). A grouping of facilities and/or release sites with area wide groundwater contamination that is not readily traceable to individual facilities or sites. Generally, a WAG would be limited to a geographically contiguous and hydrologically defined area. A WAG is synonymous with OU and SWMU.

Waste Isolation Pilot Plant (WIPP). Research and demonstration facility located at Carlsbad, New Mexico, intended to demonstrate safe disposal of TRU waste in a repository. A decision on whether to convert Waste Isolation Pilot Plant to a permanent repository for transuranic waste will be made after successful testing and operations are demonstrated.

Waste Minimization. Activities undertaken to reduce the quantities and toxicities of waste generated.

Waste Stream. Terminology used to refer to waste leaving a facility or operation.

APPENDIX C
BACKGROUND ON ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT
COST ASSESSMENT TEAM (EM-CAT)

The principal thrust in producing the Environmental Restoration and Waste Management Cost Estimating Handbook was to produce a document which could be widely used in the field. This goal meant that the end users would have to be a principal source of the information in the Handbook. Therefore, it was prepared by cost engineers with extensive field experience in the DOE process. Further, it was also intended to capture as much as possible of the environmental restoration experience to date within the Department and in fact throughout both the Government and private sectors.

This need to take a variety of disparate experiences and distill them into a Handbook required that a team be assembled, the EM-CAT. The EM-CAT process of preparing the Handbook has been largely participatory and was chaired by Kay Hudson (HQ/DP-521) and Ron Larson (ALO/FPMD).

The process was initiated between John Meinhardt (DP-50) and Tom Hindman (DP-12) with subsequent plans developed by Ed Lazur and Kay Hudson (DP-521) and John Lehr and Tom Longo (DP-124). (DP-124 later became part of the Office of Environmental Restoration and Waste Management, EM-40). An invitation to participate in the process was issued to cost and environmental personnel from the DOE community. At the first meeting, each team member presented the estimating process used at his or her field organization, especially as it affects the EM projects. (Outside speakers also were invited to address this and all subsequent meetings and provide an update on their own projects.) A comprehensive plan of action for producing the desired Handbook was developed. The draft outline of the Handbook was used as the basis for organizing task teams to prepare draft material for inclusion, and individual tasks were scheduled to match the Handbook need date. Volunteer team members to work on each section of the Handbook were organized and task chairmen selected.

A systematic approach was used in operating EM-CAT. An executive secretary was appointed for the EM-CAT. Timely and detailed minutes, including action items, were prepared for each of the meetings of the EM-CAT. Each individual working on the EM-CAT used their own organization's funds to cover time and expenses for the project. Although each task team worked on preparing only their assigned section of the Handbook, all members have reviewed and commented on the entire document.

Field Offices participated by providing support and personnel who staffed the development of the Handbook (see attached CAT membership list). In addition, the Facilities and Project Management Division, Albuquerque Operations Office funded the Executive Secretariat. The Project Management Division (DP-521) participated in materials development and funded the technical writers who pulled together the many inputs into an integrated product.

The Handbook is drawn from existing Department of Energy cost guidelines, Orders, and from Environmental Protection Agency and Army Corps of Engineers documents, where possible. However, much of the Handbook was created by the participants based on their expertise, their research, and the character of the environmental restoration process.

Upon completion of the Handbook, it was presented to EM management for final action.

The composition and organization of the EM-CAT follows:

**Kay Hudson, DP-521, HQ, Co-Chair
Ron Larson, FPMD, AL, Co-Chair
Paul Kleinen, D&M, Executive Secretary**

Recommendations regarding Guidelines for RI/FS; Program/Project Management, Remediation Activities, ED&I.

**Kyle Farmer, Mason-Hanger (Chairman)
Dan Carfagno, Mound, EG&G
Dave Campbell, HAZWRAP
Merl Lauterbach, Westinghouse
Robin Billau, INEL
Tom Longo, DP-124 HQ**

Recommendations regarding Guidelines for Contingency Application.

**Gil Mullins, Westinghouse SR (Chairman)
Bob Elliot, KAO
Blake Spilman, WHC, RL
Dan Kearney, ORO**

Recommendations regarding Cost Estimating Formats Reflecting Reporting and Review Requirements.

**Charles Oldham, MM (Chairman)
Hunter Weiler, IDO
Ken Rea, LANL**

Develop Catalog of Data Bases, and

Perform Feasibility Study of EM Data Base

**Tim McKeown, EG&G, Rocky Flats (Chairman)
Karl Sorman, EG&G, Idaho
David Wenzlaff, NTS
Don Shaner, HAZWRAP
Mike Arndt, Rockwell, RF
John Zamostny, MA-202.2, HQ**

Develop Dictionary of Terms

**Bill See, Holmes & Narver, NV (Chairman)
J.R. West, Holmes & Narver, NV
Bert Crapse, SRO
Mary Gross, SAN**

Recommendations regarding Guidelines for Escalation Application.

**Roger Freeburg, RLO (Chairman)
Keith Davis, EG&G Idaho
Craig Elliott, KEH
Forrest Day, KEH**

Develop Catalog of Cost Estimating Techniques and Methods Relevant to EM.

**Rick Shangraw, IPA (Chairman)
Steve Mellington/John Hall, NVO
Ed Merrow, IPA
Marc Zocker, LANL
Brett Schroeder, IPA**

Members-at-Large:

**Rich Hudson, RL
Tom Whalen, EPA
Haynes Goddard, EPA
R. Harve Wietbop, ACE
Brian Peckins, ACE
Ed Lazur, DP-521, HQ
Kirby Biggs, EPA**

APPENDIX D

ILLUSTRATIONS AND EXAMPLES

APPENDIX D

EXAMPLE ASSESSMENT ESTIMATE

**ESTIMATE OF COST FOR SAMPLE ASSESSMENT ACTIVITY
TITLES I, II, AND III**

DESCRIPTION	COST	PERCENT
REMEDIAL INVESTIGATION LABOR	\$240,320.00	38.88%
BASELINE RISK ASSESSMENT LABOR	\$143,440.00	23.21%
FEASIBILITY STUDY LABOR	\$234,273.20	37.91%

SUBTOTAL	\$618,033.20	100.00%
FIXED FEE (10%)	\$61,803.32	

TOTAL LABOR	\$679,836.52	
DRILLING (25 WELLS, 200 FT, SST CASING, \$14,300/EA)	\$357,500.00	
SITE SURVEYING (3 CREW DAY @ \$1200/DAY)	\$3,600.00	
ANALYTICAL LABORATORY (SEE ATTACHED SHEET)	\$97,900.00	
TRAVEL AND EXPENSES (20 DAYS @ \$100)	\$2,000.00	
EQUIPMENT USAGE (20 DAYS @ \$150)	\$3,000.00	

SUBTOTAL OTHER DIRECT COSTS	\$464,000.00	
GENERAL & ADMINISTRATIVE CHARGE (10%)	\$46,400.00	

TOTAL OTHER DIRECT COSTS	\$510,400.00	

TOTAL CONTRACT COST	\$1,190,236.52	

**ESTIMATE OF COST FOR TYPICAL ASSESSMENT ACTIVITY
CERCLA RI/FS**

ESTIMATED MANHOURS BY DISCIPLINE AND GRADE, REMEDIAL INVESTIGATION

DISCIPLINE AND GRADE	RATE	HOURS	PERCENT OF HOURS	COST	PERCENT OF COST
*****	*****	*****	*****	*****	*****
PROJECT MANAGER	\$110.00	788	26.44%	\$86,680.00	36.07%
GEOLOGIST	\$90.00	976	32.75%	\$87,840.00	36.55%
HEALTH PHYSICIST	\$90.00	344	11.54%	\$30,960.00	12.88%
HEALTH & SAFETY SPEC.	\$75.00	48	1.61%	\$3,600.00	1.50%
COMM. RELATIONS SPEC	\$70.00	48	1.61%	\$3,360.00	1.40%
QA SPECIALIST	\$65.00	56	1.88%	\$3,640.00	1.51%
FIELD TECH	\$50.00	160	5.37%	\$8,000.00	3.33%
ADMIN	\$29.00	560	18.79%	\$16,240.00	6.76%
		-----		-----	
TOTAL		2980		\$240,320.00	

**ESTIMATE OF COST FOR TYPICAL ASSESSMENT ACTIVITY
CERCLA RI/FS**

ESTIMATED MANHOURS BY DISCIPLINE AND GRADE, BASELINE RISK ASSESSMENT

DISCIPLINE AND GRADE	RATE	HOURS	PERCENT OF HOURS	COST	PERCENT OF COST

PROJECT MANAGER	\$110.00	256	14.35%	\$28,160.00	19.63%
INDUSTRIAL HYGIENIST	\$90.00	272	15.25%	\$24,480.00	17.07%
TOXICOLOGIST	\$90.00	456	25.56%	\$41,040.00	28.61%
AIR SPECIALIST	\$85.00	232	13.00%	\$19,720.00	13.75%
HYDROGEOLOGIST	\$85.00	232	13.00%	\$19,720.00	13.75%
QA SPECIALIST	\$65.00	16	0.90%	\$1,040.00	0.73%
ADMIN	\$29.00	320	17.94%	\$9,280.00	6.47%
		-----		-----	
TOTAL		1784		\$143,440.00	

**ESTIMATE OF COST FOR TYPICAL ASSESSMENT ACTIVITY
CERCLA RI/FS**

ESTIMATED MANHOURS BY DISCIPLINE AND GRADE, FEASIBILITY STUDY

DISCIPLINE AND GRADE	RATE	HOURS	PERCENT OF HOURS	COST	PERCENT OF COST
*****	*****	*****	*****	*****	*****
PROJECT MANAGER	\$110.00	712	17.35%	\$78,320.00	33.43%
GEOLOGIST	\$61.76	480	11.70%	\$29,644.80	12.65%
HEALTH PHYSICIST	\$53.44	552	13.45%	\$29,498.88	12.59%
DESIGN ENGINEER	\$45.59	904	22.03%	\$41,213.36	17.59%
COST ENGINEER	\$27.38	224	5.46%	\$6,133.12	2.62%
INDUSTRIAL HYGIENIST	\$61.76	328	7.99%	\$20,257.28	8.65%
TOXICOLOGIST	\$40.96	328	7.99%	\$13,434.88	5.73%
ADMIN	\$27.38	576	14.04%	\$15,770.88	6.73%
		-----		-----	
TOTAL		4104		\$234,273.20	

**ESTIMATE OF COST FOR TYPICAL ASSESSMENT ACTIVITY
CERCLA RI/FS**

SAMPLE ANALYSIS COSTS

DESCRIPTION -----	PRICE -----	QUANTITY -----	COST -----
EP TOXICITY SOILS	\$200	200	\$40,000.00
PRIORITY POLLUTANTS WATER	\$200	25	\$5,000.00
TPH SOILS	\$60	100	\$6,000.00
TPH WATER	\$60	25	\$1,500.00
TVH WATER	\$60	25	\$1,500.00
TVH SOILS	\$64	100	\$6,400.00
EPA METHOD 8010/8020	\$125	100	\$12,500.00
F LISTED SOLVENTS SOIL	\$500	25	\$12,500.00
F-LISTED SOLVENTS WATER	\$500	25	\$12,500.00

			\$97,900.00

NOTES

SAMPLE TURNAROUND TIME IS 15 DAYS

PRICE INCLUDES: BOTTLES, COOLERS, BLUE ICE, TRIP BLANKS, AND SHIP

ESTIMATE OF COST FOR TYPICAL ASSESSMENT ACTIVITY
CERCLA RI/FS

ESTIMATED MANHOURS - REMEDIAL INVESTIGATION

TITLE	PROJ MGR	GEOLOG.	HEALTH PHYS	HEALTH & SAF.	COMM RELAT	FIELD		ADMIN	TOTAL
						QA	TECH		
PLANNING									
SCOPE	40	40	16	0	0	8	0	40	144
COST	40	40	16	8	8	8	0	40	160
WORK PLAN									
BACKGROUND DATA	8	40	8	0	0	0	0	0	56
DATA REVIEW/ANALYSIS	8	24	8	0	0	0	0	0	40
IDENTIFY ALTS	8	24	8	0	0	0	0	0	40
REG. REVIEW/ARARS	0	24	8	0	0	0	0	0	32
DEVELOP DOGS	8	24	8	0	0	40	0	0	80
REPORT PREP	24	40	8	0	0	0	0	0	72
COMMUNITY RELATIONS PLAN	8	0	0	0	40	0	0	0	48
PROJECT MGMT PLAN	24	0	0	0	0	0	0	0	24
SAMPLING & ANA. PLAN	8	24	16	0	0	0	0	0	48
HEALTH & SAFETY PLAN	4	0	0	40	0	0	0	0	44
ISSUE DRAFT WORK PLAN	24	8	8	0	0	0	0	160	200
INCORPORATE COMMENTS									
DOE/INSTALLATION	40	0	0	0	0	0	0	0	40
EPA/STATE	40	0	0	0	0	0	0	0	40
ISSUE FINAL WORK PLAN	40	24	0	0	0	0	0	0	64
FIELD WORK									
BID/SELECT SUBCONTRACTORS	24	24	0	0	0	0	0	0	48
SAMPLE COLLECTION	24	80	40	0	0	0	160	0	304
SAMPLE ANALYSIS	24	40	40	0	0	0	0	0	104
RI REPORT									
SOURCE CHARACTERIZATION	8	40	0	0	0	0	0	8	56
AIR QUALITY	8	0	0	0	0	0	0	8	16
SURFACE WATER	8	40	0	0	0	0	0	8	56
GAS MIGRATION	8	40	0	0	0	0	0	8	56
RADIOLOGICAL	8	0	120	0	0	0	0	8	136
SURFACE/SUB SOIL	8	80	0	0	0	0	0	8	96
CAP INTEGRITY	8	40	0	0	0	0	0	8	56
HYDROGEOLOGY	8	80	0	0	0	0	0	8	96
RESIDENTIAL WATER	8	40	0	0	0	0	0	8	56
EXIST MONITORING WELLS	8	40	0	0	0	0	0	8	56
ISSUE DRAFT RI REPORT	32	40	40	0	0	0	0	40	152
INCORPORATE COMMENTS									
DOE/INSTALLATION	40	40	0	0	0	0	0	80	160
EPA/STATE	40	40	0	0	0	0	0	80	160
ISSUE FINAL RI REPORT									
PROGRESS MEETINGS	200	0	0	0	0	0	0	40	240
	***	***	***	***	***	***	***	***	***
	788	976	344	48	48	56	160	560	2980

ESTIMATE OF COST FOR TYPICAL ASSESSMENT ACTIVITY
CERCLA RI/FS

ESTIMATED MANHOURS - BASELINE RISK ASSESSMENT

TITLE	PROJ MGR	IND. HYG.	TOXICOL	AIR SPEC	HYDRO GEO	QA	ADMIN	TOTAL

RISK ASSESSMENT								
HAZARDOUS CHEMICALS	8	0	24	0	0	0	0	32
PROPOSED INDICATOR CHEMICAL	8	24	24	0	0	0	0	56
EXPOSURE SCENARIOS	8	40	40	24	24	0	0	136
PATHWAY ANALYSIS	8	40	40	80	80	0	0	248
TOXICITY ASSESSMENT CRITERI	8	0	120	0	0	0	0	128
RISK CHARACTERIZATION	8	40	80	0	0	0	0	128
ISSUE DRAFT	40	40	40	40	40	8	160	208
INCORPORATE COMMENTS								
DOE/INSTALLATION	24	24	24	24	24	0	0	120
EPA/STATE	24	24	24	24	24	0	0	120
ISSUE FINAL	40	40	40	40	40	8	160	208
PROGRESS MEETINGS	80	0	0	0	0	0	0	80
	***	***	***	***	***	***	***	***
TOTAL	256	272	456	232	232	16	320	1464

ESTIMATE OF COST FOR TYPICAL ASSESSMENT ACTIVITY
CERCLA RI/FS

ESTIMATED MANHOURS - FEASIBILITY STUDY

TITLE	PROJ	HEALTH		DESIGN	COST	IND.		ADMIN	TOTAL
	MGR	GEOLOG.	PHYS	ENG	EST	HYG.	TOXICO		
PLANNING & SCOPING	40	40	40	40	40	40	40	40	240
FEASIBILITY STUDY REPORT									
SCREEN TECHNOLOGY	40	40	40	40	40	40	40	40	240
SCREEN PROCESS OPTIONS	8	0	24	80	80	0	0	0	192
ENDANGERMENT ASSESSMENT	8	0	40	0	0	80	80	0	128
ALTERNATIVE DEVEL.	8	0	0	120	0	0	0	0	128
TREATABILITY STUDY	8	0	0	120	0	0	0	0	128
ISSUE DRAFT REPORT	40	0	24	120	40	0	0	120	224
INCORPORATE COMMENTS									
DOE/INSTALLATION	40	40	40	40	0	24	24	40	184
EPA/STATE	40	40	40	40	8	24	24	40	184
PUBLIC	40	40	40	40	0	24	24	40	184
RECORD OF DECISION									
PREPARE ROD	80	80	80	80	24	24	24	80	368
ISSUE DRAFT ROD	40	40	24	24	0	0	0	40	128
INCORPORATE COMMENTS									
DOE/INSTALLATION	40	40	40	40	0	24	24	24	184
EPA/STATE	40	40	40	40	0	24	24	24	184
PUBLIC	40	40	40	40	0	24	24	24	184
ISSUE FINAL ROD	40	40	40	40	0	0	0	24	160
PROGRESS MEETINGS	160	0	0	0	0	0	0	40	160
	***	***	***	***	***	***	***	***	***
TOTAL	712	480	552	904	224	328	328	576	3200

APPENDIX D

EXAMPLE CLEAN-UP ESTIMATE

Cleanup of the XYZ Project

Basis of the Estimate

Task Description

The goal of this cleanup is to prevent and mitigate the migration of hazardous substances due to chemical dumping. Contaminated media include soil, groundwater, surface water, and air. Classes of contaminants at the site consist of heavy metals, volatile organic compounds and other organics. The remedial activities planned for this site include: construction of a groundwater leachate collection trench, a clay cap, upgradient slurry wall, active gas collection and treatment system, and a security fence; dewatering; excavation, and filling of the leachate ponds and lagoons; implementation of surface water controls; a monitoring program over 30 year period; and collection and treatment of groundwater/leachate from the trench (treatment preference is pretreatment and discharge to a POTW). (For more information on site and remedies see Activity Data Sheet for XYZ Project, 1988)

Basis of the Cost Estimate¹

Cost estimates for the remedial action tasks are based on unit cost figures. These unit costs are based on both vendor quotes and the average cost from a sample of unit cost figures from similar cleanup sites. Units of measure and unit prices are listed in the cost breakdown table. Unless noted these unit costs cover both material and labor costs. Detailed below are the major cost categories, the sources of the unit costs, and any assumptions made about the costs:

Site Preparation: Unit cost numbers for site preparation activities are based on vendor quotes. The firms providing the quotes and the dates of the quotes are shown in the table below:

<u>Task</u>	<u>Firm</u>	<u>Date</u>	<u>Unit Cost</u>
-------------	-------------	-------------	------------------

Assumptions: (list assumptions)

Construction Cap: Unit cost numbers for cap construction are provided by vendor quotes. The firms providing the quotes and the dates of the quotes are shown below:

<u>Task</u>	<u>Firm</u>	<u>Date</u>	<u>Unit Cost</u>
-------------	-------------	-------------	------------------

Assumptions: (list assumptions)

Gas Collection and Treatment Facility: Unit cost numbers obtained for this facility are based on a similar facility constructed for the X project. A factor is used to scale the facility to the appropriate site. This factor is X and is derived from "Cost Estimating for Process Plants." Other assumptions concerning this facility include: (list assumptions)

¹ This is a condensed version of a typical basis of the cost estimate. The purpose is to demonstrate the types of information and level of detail that is required. It is presented for illustrative purposes only.

Groundwater Collection and Pretreatment Facility: Unit cost numbers obtained for this facility are based on a similar facility constructed for the X project. A factor is used to scale the facility to the appropriate site. This factor is X and is derived from "Cost Estimating for Process Plants." Other assumptions concerning this facility include: (list assumptions).

Laboratory Facilities: Unit cost numbers obtained for this facility are based on a similar facility constructed for the X project. A factor of X is used to scale the facility to the appropriate site and was obtained from XX construction company. Other assumptions concerning this facility include: (list assumptions).

Engineering and design, project management, and administration estimates are based on fully loaded (all G & A) quotes from three major environmental firms. These firms are: firm one; firm two; and firm three. Estimates are derived based on the average cost per manhour by labor category.

Escalation

Costs are escalated by cost category from 1990 dollars using ICE supplied rates (p. 7-3 of CAT Handbook). In compliance with guidance for applying escalation to ER projects, escalation was applied from the date the estimate was made to the midpoint of the performance schedule. Shown below are the derivation of escalation factors for the major cost categories:

1. Remedial Design (midpoint = 09/01/91)

FY-Period Years x Escalation Index = Escalation Factor

07/01/90 - 10/01/90	3/12	0.048	0.012
10/01/90 - 9/01/91	11/12	0.052	0.048

Compound Escalation Factor = $1.012 \times 1.048 = 6.05\%$

2. Remedial Action (midpoint 03/01/93)

FY-Period Years x Escalation Index = Escalation Factor

07/01/90 - 10/01/90	3/12	0.048	0.012
10/01/90 - 10/01/91	1.0	0.052	0.052
10/01/91 - 10/01/92	1.0	0.056	0.056
10/01/92 - 03/01/93	5/12	0.058	0.024

Compound Escalation Factor =
 $1.012 \times 1.052 \times 1.056 \times 1.024 = 15.1\%$

3. Equipment Procurement (midpoint 07/01/91)

FY-Period Years x Escalation Index = Escalation Factor

07/01/90 - 10/01/90	3/12	0.048	0.012
10/01/91 - 07/01/91	10/12	0.052	0.043

Compound Escalation Factor = $1.012 \times 1.043 = 5.56\%$

4. Project Management (midpoint 04/01/92)

FY-Period Years x Escalation Index = Escalation Factor

07/01/90 - 10/01/90	3/12	0.048	0.012
10/01/90 - 10/01/91	1.0	0.052	0.052
10/01/91 - 04/01/92	6/12	0.056	0.028

$$\text{Compound Escalation Factor} = 1.012 \cdot 1.052 \cdot 1.028 = 9.44\%$$

The compound escalation factors are applied to the total costs for each category. Total project escalation is the summation of escalation for all activities.

Contingency Analysis

Contingency is applied to each of the cost elements in order to weight the degree of uncertainty associated with separate cost categories. The contingencies are based on the guidance provided in Chapter 6 of the CAT Handbook. The overall contingency for the project is 27.2 percent. Contingency by cost category is provided below:

Contingency Summary for Cleanup

Project Title: Cleanup of XYZ Project

Location:

<u>Element of cost</u>	<u>Base Cost</u> <u>('000\$)</u>	<u>Contingency</u> <u>Percent</u>	<u>('000\$)</u>
Remedial Design			
Preliminary Design	1,319	10%	132
Definitive Design	3,077	15%	462
Construction Manag.	4,246	10%	425
Remedial Action			
Site Preparation	3,136	20%	627
Construction of Cap	26,986	35%	9,445
Gas Collection & Treatment Facility	5,818	25%	1,455
Groundwater Collection & Pretreatment Fac.	3,393	30%	1,018
Laboratory Facilities	4,498	28%	1,259
Task Management	438	10%	44
Standard Equipment	2,191	5%	110
	<u>55,102</u>	<u>27.2</u>	<u>14,985*</u>

Total Estimated Cost (TEC)

$$= 55,102,000 + 14,985,000 = 70,087,000$$

(*Note: Figures do not sum exactly due to rounding)

**ESTIMATE FORMAT FOR
ENVIRONMENTAL RESTORATION
CLEAN-UP**

Task Title: Cleanup of XYZ Project
Task Number: 61277
Operations Office:
Installation:
Regulatory Designation: CERCLA
Estimate Type: Preliminary
Estimate Date: 7/90
B & R Code: EW-20-10-10

<u>CATEGORY</u>	AS SPENT DOLLARS X 1000
Remedial Design	8,642
Preliminary Design	1,319
Definitive Design	3,077
Construction Management	4,246
Land and Land Rights	0
Remedial Action (CM or RA)	43,831
Site Preparation	3,136
Construction of Cap	26,986
Gas Collection and Treatment Facility	5,818
Groundwater Collection and Pretreatment Facility	3,393
Laboratory Facilities	4,498
Task Management	438
Standard Equipment	2,191
Contingency	14,985
Total Estimated Cost	70,087

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**Breakdown of Costs
for Project XYZ**

Description of Task	Number of Units	Unit Measure	Unit Price	Estimated Cost
Site Preparation				
Site grading, drainage, roads and parking lots	1	Lot Size		921,815.00
Fence, chain link, and gates	1	Lot Size		218,119.00
Field-erected steel tanks (plus installation)	2	Tanks	360,000	1,232,670.00
Electrical work	1	Lot Size		606,683.00
Dewatering and cleanup of lagoons	17,000	Tons	9.23	156,910.00
Construction of Cap				
Site grading for multilayer cap subgrade	605,500	Tons	9.64	5,837,020.00
Multilayer cap	387,200	Square Yards	32.87	12,727,264.00
Additional clay for cap	13,000	Tons	12.72	165,360.00
Additional common material for cap	5,500	Tons	15.41	84,755.00
Soil cutoff wall	399,500	Square Feet	7.74	3,092,130.00
Roller compacted concrete	33,700	Cubic Yards	150.73	5,079,601.00
Gas Collection and Treatment Facility				
Construction of gas-collection stone layer	359,100	Square Yards	10.58	3,799,278.00
Landfill gas collection system	1	Lot Size		524,729.00
Gas Treatment facility	1	Lot Size		1,494,444.00
Groundwater Collection and Pretreatment Facility				
Leachate/groundwater collection system	1	Lot Size		1,852,102.00
Pretreatment facility	1	Lot Size		1,541,331.00

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Summary Task Schedule for Site XYZ

APPENDIX D

ARTICLES

AN UPDATE ON HSWA

By Ralph Golia and Phil Stapleton

Planning for solid waste management units early in the permitting process can facilitate compliance and reduce investigative costs.

Ralph Golia is a geohydrologist specializing in hazardous waste management in Dames & Moore's Philadelphia office. Phil Stapleton directs the firm's environmental regulations services in Washington, D.C.

In 1984 Congress passed the Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA). The HSWA greatly expanded the U.S. Environmental Protection Agency's (EPA) authorities under RCRA for requiring corrective action for releases of hazardous wastes and constituents at facilities that manage hazardous waste. During 1989, it is anticipated that the EPA will promulgate the final regulations for corrective action under HSWA. These regulations will define the EPA's overall approach to the investigation and cleanup of environmental contamination, provide a framework for corrective action under RCRA Section 3004(u) and establish guidelines for administrative orders requiring corrective action under Section 3008(h) of RCRA.

RCRA Section 3004(u) applies to facilities subject to RCRA permits, including post-closure permits for land disposal facilities. For facilities that received RCRA permits prior to the enactment of HSWA (November 8, 1984), corrective action provisions may be imposed upon permit renewal. Section 3008(h) corrective action requirements apply to facilities under interim status.

Note that there are many details of the HSWA and the corrective action program that are too complex to discuss here. The RCRA corrective action authorities are broad and apply to facilities regardless of whether they are continuing operations or closing waste management operations. Also, these requirements apply regardless of whether a facility, or part of it, is subject to action under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) of 1980 as amended in 1986.

Requirements of HSWA

Some of the major provisions of the HSWA include requirements that the EPA:

- Issue, by November 1988, all permits for landfills, surface impoundments, land treatment plots, or waste piles, and request RCRA Part B Permit applications from other facilities (primarily storage facilities).

- Issue regulations that establish treatment standards for hazardous wastes or ban such waste streams from land disposal.
- Require industry to establish waste minimization programs.
- Ascertain whether a facility that requires a permit for an active unit has any solid waste management units (SWMUs) that may be a source of a continuing release. An SWMU is any waste management unit, regardless of when used, and may include landfills, surface impoundments, land treatment units, tanks, and so forth. In addition to these units, certain areas associated with production processes that have routine, systematic and deliberate releases of wastes, are also considered SWMUs. If SWMUs are discovered, the facility is required to conduct an investigation to determine their environmental impact and, if necessary, to conduct corrective action.

The Corrective Action Program

A Corrective Action Permit is usually issued by the EPA as a separate part of the RCRA Permit, with the other part being the familiar Part B. The EPA has developed a four-phase approach for implementing the RCRA corrective action program under Section 3004(u). Details for conducting the four phases (the RCRA facility assessment (RFA), the RCRA facility investigation (RFI), the corrective measures study (CMS) and the corrective measures implementation (CMI)) are shown on the chart.

The objective of the RFA is to identify potential sources of release and to eliminate from consideration areas with little or no potential for environmental contamination. This task has been typically completed by the agency as required by the statute. However, Dames & Moore's experience with recently issued permits indicates that in certain instances, the agency is requesting that the facility conduct some to most of this work. This request that the facility conduct the RFA should benefit the agency and the facility. The EPA saves time and expenses, and the facility is given the opportunity to address SWMUs

If SWMUs are discovered, the facility is required to conduct an investigation . . .

AN UPDATE ON HSWA

early in the permitting process, and possibly to avoid the preparation of work plans and the conduct of investigations (RFIs).

The RFI is modeled on the Superfund program's remedial investigation activities. Based on the HSWA permits that Dames & Moore has reviewed, the requirements involved in conducting RFIs generally include compiling a list of SWMUs that can range from a closed landfill to an active underground storage tank. The RFI typically requires the facility to:

- Provide a complete description of regional hydrogeology and climatic conditions.
- Define the areal extent of any release (both on- and off-site).
- Provide a complete description of site hydrogeology, including horizontal and vertical gradients, and a complete characterization of the physical and chemical properties of the soil.
- Characterize the physical and chemical properties and the hydrology of any on-site or adjacent surface-water body. This characterization includes flow rate, nutrients, and sediments (biologic oxygen demand, chemical oxygen demand, and so forth).

- Identify any potential receptors (human and animal) and perform a risk assessment.
- Develop a community relations plan.
- Identify technologies involved in all potential corrective measures to address any potential releases.

In addition, some RFIs include requirements to conduct an air monitoring program, and most RFIs require the facility to develop a work plan that explains the technical approach to the problems, a project management plan, a data management plan, a data collection quality control plan, and a health and safety plan to be submitted for agency approval prior to implementation.

Companies that have received their Corrective Action Permit with RFI requirements should conduct effective and focused investigations. Some changes to the RFI requirements may be possible through the permit modification process. For companies that have been given the opportunity to perform portions of the RFA, an extensive

The RCRA (Resource Conservation and Recovery Act) facility investigation, a key part of the U.S. Environmental Protection Agency's corrective action program under the Hazardous and Solid Waste Amendments, seeks new ground for RCRA by requiring air sampling programs at some facilities.

The RCRA facility investigation also requires comprehensive assessment of subsurface conditions, including the horizontal and areal extent of contamination.

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