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US Army Corps
of Engineers®

A GUIDE TO PREPARING AND REVIEWING REMEDIAL ACTION REPORTS OF COST AND PERFORMANCE

ENGINEER PAMPHLET

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	A GUIDE TO PREPARING AND REVIEWING REMEDIAL ACTION REPORTS OF COST AND PERFORMANCE	
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FOREWARD

The U.S. Army Corps of Engineers (USACE), through its staff and contractors, provides quality, responsive engineering and construction services to the Army and the Nation. USACE missions include civil works, military construction, environmental restoration and support to other agencies. The civil works program encompasses flood control, navigation, shore erosion, and recreation facilities. The military construction program supports the Army, most of the Air Force, and certain other Department of Defense (DoD) agencies. USACE performs environmental restoration work for the Army, DoD, Environmental Protection Agency, Department of Energy, and several other agencies. USACE also provides design and construction management services for non-DoD Federal agencies, state and local governments, and foreign governments.

A majority of the planning, engineering, design and surveying and mapping services for these programs is acquired by contract with private architect-engineer (A-E) firms. USACE is one of the largest Federal procurers of A-E services. This pamphlet describes the USACE policies and procedures for preparing and reviewing remedial action reports of cost and performance.

FOR THE COMMANDER:

ROBERT CREAR
Colonel, Corps of Engineers
Chief of Staff

This pamphlet supersedes EP 1110-1-19, dated 15 November 1996.

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
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Engineering and Design
A GUIDE TO PREPARING AND REVIEWING REMEDIAL ACTION REPORTS OF COST AND PERFORMANCE

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LIST OF EXHIBITS

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ACRONYMS

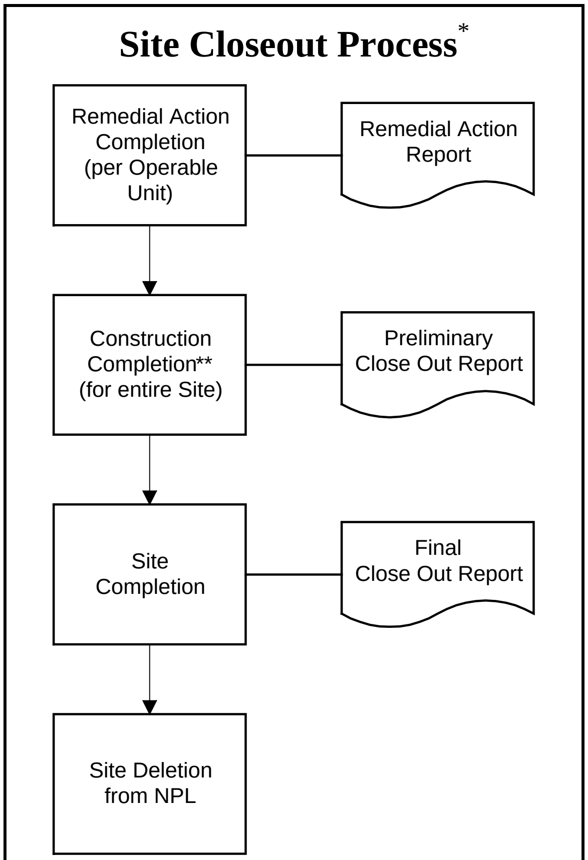
ARARs	Applicable or Appropriate and Relevant Requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CX	Center of Expertise
DoD	Department of Defense
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FF	Federal Facility
FFA	Federal Facility Agreement
FS	Feasibility Study*
HCAS	Historical Cost Analysis System
HQ	Headquarters
HRS	Hazard Ranking System
HTRW	Hazardous, Toxic, and Radioactive Waste
LTRA	Long-Term Response Action*
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&F	Operational and Functional*
O&M	Operation and Maintenance*
OU	Operable Unit*
PA	Preliminary Assessment
PRP	Potentially Responsible Party*
PRP LR	Potentially Responsible Party Long-Term Response*
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action*
RD	Remedial Design*
RI	Remedial Investigation*
ROD	Record of Decision*
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act
SI	Site Inspection
USACE	U.S. Army Corps of Engineers
WBS	Work Breakdown Structure

* Definition provided in Appendix A

CHAPTER 1
INTRODUCTION

1-1. Purpose.

a. This pamphlet defines the procedures for formally documenting and reporting cost and performance information from U.S. Army Corps of Engineers (USACE) environmental restoration[1] projects and provides guidance to the project team for scoping the types of data to collect and how they are presented. Customers must have complete, accurate, and timely information for proper operation and maintenance, as a baseline for system modifications and optimization, and to document information that may be used in conjunction with a long-term response action or recurring review. This information will also address information to plan and tailor their site completion and individual operable units (OUs) for site closeout.



* This example incorporates the Superfund process.

** Occurs when construction is complete at final OU that requires construction. Therefore, construction completion for the site may occur prior to RA completion at the final OU.

b. This pamphlet, or guide, provides a current reference for preparing and reviewing remedial action (RA) reports at the completion of remedial action at a waste site operable unit. The goals of this guide include improving the consistency and completeness of RA reports while ensuring that key observations and lessons learned during remedy implementation, including cost and performance data, are adequately documented. Specifically, this guide is intended to ensure that sufficiently detailed RA cost data is furnished for input into the Historical Cost Analysis System (HCAS) which requires the use of the Hazardous, Toxic, and Radioactive Waste (HTRW) RA work breakdown structure (WBS).

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[1] As used by this guide, "environmental restoration" refers to the Superfund programs operated under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act (SARA) of 1986. In many cases there is not a straightforward relationship between the U.S. Environmental Protection Agency (EPA) Superfund and Department of Defense (DoD) terms. Users of this document should recognize that in most cases, these requirements may not be consistent with other programs. The environmental project team should discuss, plan, and tailor their site documentation efforts to facilitate the environmental requirements at their site.

c. This guide is intended to assist in the preparation, review, or use of RA reports for environmental restoration projects by cost engineers, environmental engineers, resident construction managers, project managers, remedial project managers (RPMs), program managers, and other related technical disciplines.

1-2. Applicability. This pamphlet applies to all USACE commands having investigation, design, and remedial action responsibility for environmental restoration projects within the military, civil works, or support for others programs.

1-3. Scope. This pamphlet is a companion document to *A Guide for Preparing and Reviewing Remedial Action Reports* developed jointly by the U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (USEPA). The primary difference between these two documents is the cost reporting format. Both documents incorporate selected guidance from the *Guide to Documenting and Managing Cost and Performance Information for Remediation Projects* (EPA 542-B-98-007, October 1998). This guide does not address construction completion, site completion, or site deletion from the National Priorities List (NPL). For information on these issues refer to *Close Out Procedures for National Priorities List Sites* (EPA 540-R-98-016, January 2000). Although much of this guide is written from the perspective of a Superfund site listed on the NPL, the presented concepts could also be applied to non-NPL sites or other cleanup programs.

1-4. References. The following documents provide additional information related to the subject of this pamphlet.

a. ER 5-1-11. Program and Project Management.

b. ER 415-345-38. Transfer and Warranties.

c. ER 1110-3-1301. Hazardous, Toxic, and Radioactive Waste (HTRW) Cost Engineering.

d. CEGS 01070. Cost and Performance Report.

e. CEGS 01440. Contractor Quality Control.

f. CEGS 01450. Chemical Data Quality Control.

g. Standard Industrial Classification Manual. 1987.

h. 40 CFR Part 300. National Oil and Hazardous Substances Pollution Contingency Plan (NCP). (*http://www.epa.gov/docs/epacfr40/chapt-I.info/subch-J.htm*)

i. EPA 540-F-93-048. Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Site with Volatile Organic Compounds in Soils. U.S. Environmental Protection Agency. September 1993.

j. EPA/542/B-94/013. Remediation Technologies Screening Matrix and Reference Guide, Second Edition. Federal Remediation Technologies Roundtable. October 1994.

k. EPA/540/G-89/004. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. U.S. Environmental Protection Agency. October 1988.

l. OSWER 9335.0-27FS. A Guide to Selecting Superfund Remedial Actions. U.S. Environmental Protection Agency. April 1990.

m. EPA 540/F-96/018. The Role of Cost in the Superfund Remedy Selection Process. Quick Reference Fact Sheet. U.S. Environmental Protection Agency. September 1996. (*http://www.epa.gov/superfund/resources/cost_dir/index.htm*)

n. EPA 540-R-97-013. Rules of Thumb for Superfund Remedy Selection. U.S. Environmental Protection Agency. August 1997. (*http://www.epa.gov/superfund/resources/rules/index.htm*)

o. EPA 542-B-98-007. Guide to Documenting and Managing Cost and Performance Information for Remediation Projects. U.S. Environmental Protection Agency. October 1998. (*http://www.frtr.gov/cost/*)

p. EPA/540/R-98/031. A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents. U.S. Environmental Protection Agency. July 1999. (*http://www.epa.gov/superfund/resources/remedy/rods/index.htm*)

q. EPA 540-R-98-016. Close Out Procedures for National Priorities List Sites. U.S. Environmental Protection Agency. January 2000. (*http://www.epa.gov/superfund/resources/closeout/index.htm*)

r. EPA 540-R-00-002. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. U.S. Environmental Protection Agency. July 2000. (*http://www.epa.gov/superfund/resources/remedy/costest.htm*)

1-5. Organization. This guide is intended to provide the user with the basic information necessary to complete or review the RA report for a given OU at a site. Throughout the guide, exhibits help illustrate the concepts discussed, while highlight boxes are used to provide information that is important to note, but not necessarily central to the discussion at hand. The objectives of each chapter and appendix are listed below.

a. Chapter 1: Introduce the guide, including its purpose, scope, and use.

b. Chapter 2: Provide background information on RAs, including the Superfund process, RA process, and RA completion.

c. Chapter 3: Provide RA reporting criteria, including who should prepare the RA report, timing of submittals, distribution, approval criteria, and a checklist of RA report components.

d. Chapter 4: Describe the components of the recommended RA report format and describe the information that should be included in each component.

e. Chapter 5: Provide information on how to document technology performance in the RA report.

f. Chapter 6: Provide information on how to document project costs in the RA report.

g. Appendix A: Provide a glossary of environmental restoration terms used in the guide.

h. Appendix B: Present an example RA report for the case of ex situ soil remediation using incineration.

i. Appendix C: Present an example RA report for a combination of in situ soil and groundwater remediation using soil vapor extraction and air sparging.

j. Appendix D: Provide example templates for reporting costs for HCAS data entry.

CHAPTER 2
BACKGROUND

2-1. Superfund Process.

a. General

(1) Section 105 of CERCLA, as amended by SARA, requires the U.S. Environmental Protection Agency (EPA) to maintain the NPL, which is a record of uncontrolled hazardous waste sites that have released or that pose a threat to release hazardous substances into the environment. Pursuant to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Title 40 Code of Federal Regulations Part 300 (40 CFR 300), sites on the NPL are eligible to receive CERCLA trust fund (Superfund) financing for RAs. Funding can only be provided for RAs at sites that are listed as final on the NPL.

(2) Prior to a site being listed on the NPL, a preliminary assessment/site inspection (PA/SI) is typically completed to collect the data necessary to develop a score for the site using the hazard ranking system (HRS). The HRS score ultimately determines the site's eligibility for inclusion on the NPL.

Lead Agencies

At or prior to the time a site is placed on the NPL, a determination of the lead agency is made. The lead agency, represented by a remedial project manager (RPM), has the primary responsibility for coordinating response action. EPA, a State environmental agency, or another Federal agency can serve as the lead agency. However, EPA retains final remedy selection authority for all "Fund-financed" actions, and for all Federal facility (FF)-led actions at NPL sites.* Generally, the lead agency RPM is responsible for overseeing all technical, enforcement, and financial aspects of a remedial response.

* The following terms are typically used to designate which government entity serves as the lead agency in the Superfund remedial response process: "EPA-lead," "State-lead," and "Federal facility-lead." In addition, the following terms refer to the source of remediation/cleanup monies: "Fund-financed" (i.e., remediation or cleanup money from the Superfund trust fund) and "potentially responsible party (PRP)-lead" (i.e., remediation or cleanup money derived from enforcement action taken by lead agency).

(3) Sites on the NPL are addressed by the Superfund process through a combination of removal and remedial authority. Removal actions are short-term responses, usually to address immediate threats.[1] Remedial actions achieve long-term permanent responses to risk. The Superfund pipeline (Exhibit 2-1) illustrates the major phases and decision points of the Superfund remedial response process. The various phases of this process are briefly described in the following paragraphs.

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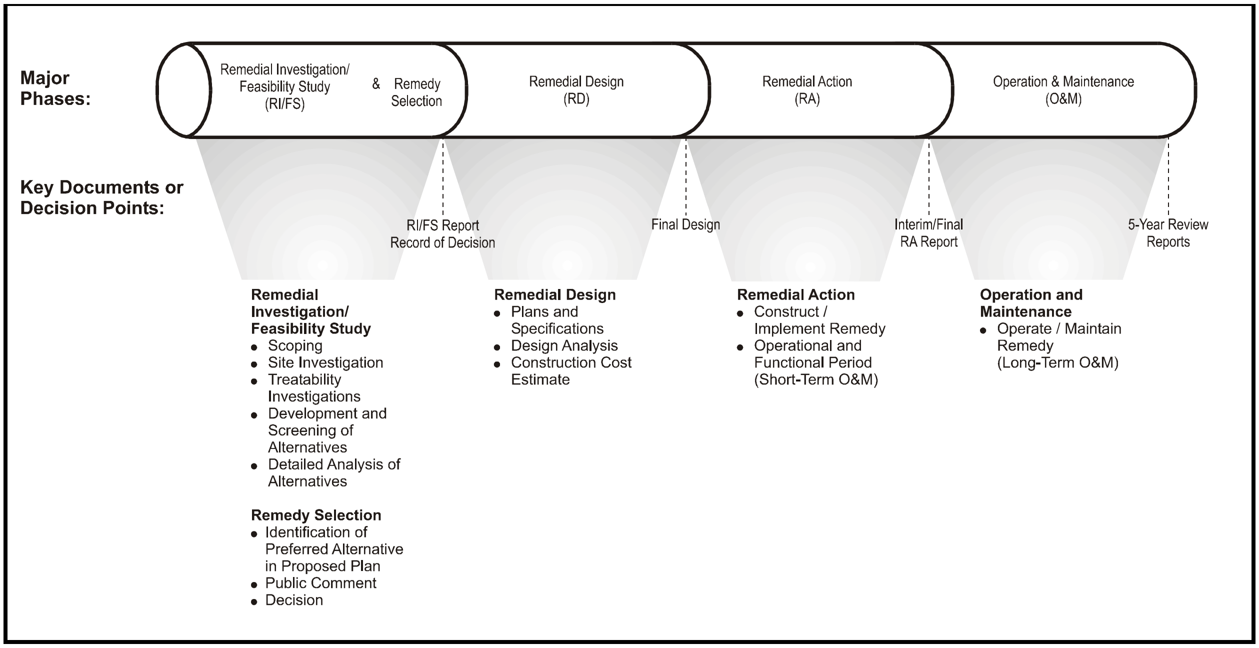
[1] Removal authority cleanup actions achieve prompt risk reduction through activities categorized as emergency (response required within hours/days), time-critical (response required within 6 months), or non-time-critical (more than 6 months is available before action must be taken). Non-time-critical removal alternatives are analyzed in an engineering evaluation/cost analysis (EE/CA), which is considered the equivalent of a remedial investigation/feasibility study. An action memorandum is the primary decision document, which is considered the equivalent of a record of decision.

Exhibit 2-1
The Superfund Pipeline



b. Remedial Investigation/Feasibility Study

(1) The remedial investigation/feasibility study (RI/FS) process is initiated at the time of a site's listing on the NPL. The RI/FS gathers the information necessary to select a remedy that will meet the statutory and regulatory requirements of the Superfund cleanup program.

(2) The objective of the RI is to collect the data necessary to assess the current and future potential risks to human health and the environment, and to support the development, evaluation and selection of appropriate response alternatives. The RI may be performed in several stages so that the investigation is refined as it progresses. The RI includes field investigations, treatability studies, a baseline risk assessment, and the initial identification of applicable or relevant and appropriate requirements (ARARs) (i.e., all State and Federal laws outside Superfund regulations that warrant consideration).

(3) The FS begins by formulating viable alternatives. This requires that contaminants of concern, potential exposure pathways, remediation objectives/cleanup goals, general response actions, subject volumes or areas of media, and potentially applicable technologies be identified.

An FS may address a specific site problem, OU, or an entire site.[2] Following the preliminary screening of alternatives, a reasonable number of possible alternatives undergo a detailed analysis using the nine evaluation criteria listed in the NCP.

c. Remedy Selection

(1) The preferred alternative remedy for a site or OU is discussed in detail and presented for public comment in the proposed plan. The proposed plan briefly summarizes the alternatives that were studied in detail during the RI/FS, and highlights the key factors that lead to the selection of the preferred alternative.

(2) Following the public comment period associated with the proposed plan, the ROD documents the selected remedy.[3] The ROD introduces the significant facts, presents an analysis of these facts, states the site-specific policy determinations, and explains how the nine evaluation criteria were considered in the remedy selection process. The remedy selection process must be carried out in accordance with CERCLA and, to the extent practicable, with the NCP.

(3) The ROD provides the framework for the transition into the next phase of the remedial process. Recommended content and format for the ROD can be found in *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (EPA 540-R-98-031, July 1999). The ROD describes the remedy's technical parameters, specifying the methods selected to protect human health and the environment, including the treatment, engineering, institutional control components, and remedial action objectives/cleanup goals. The ROD also provides a consolidated summary of the site or OU and the chosen remedy, including the rationale behind the selection.

Potentially Responsible Parties

Under CERCLA §104, a person or an entity potentially responsible for a release of hazardous substances, pollutants, or contaminants into the environment (i.e., a potentially responsible party (PRP)) may be allowed to conduct certain response actions in accordance with CERCLA §122, if a lead agency determines that the PRP, or the PRP's contractor, is qualified and capable. For a PRP-lead response action, either EPA or the state agency oversees the PRP's work and develops the ROD.* PRPs may participate in the remedy selection process by submitting comments on the proposed plan during the formal public comment period, held prior to the final remedy selection. However, PRPs generally should not be permitted to write or amend a ROD.

* For detailed information regarding PRP oversight, refer to *Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies*, Volumes 1 and 2 (EPA 540-G-91010a and b, July 1991).

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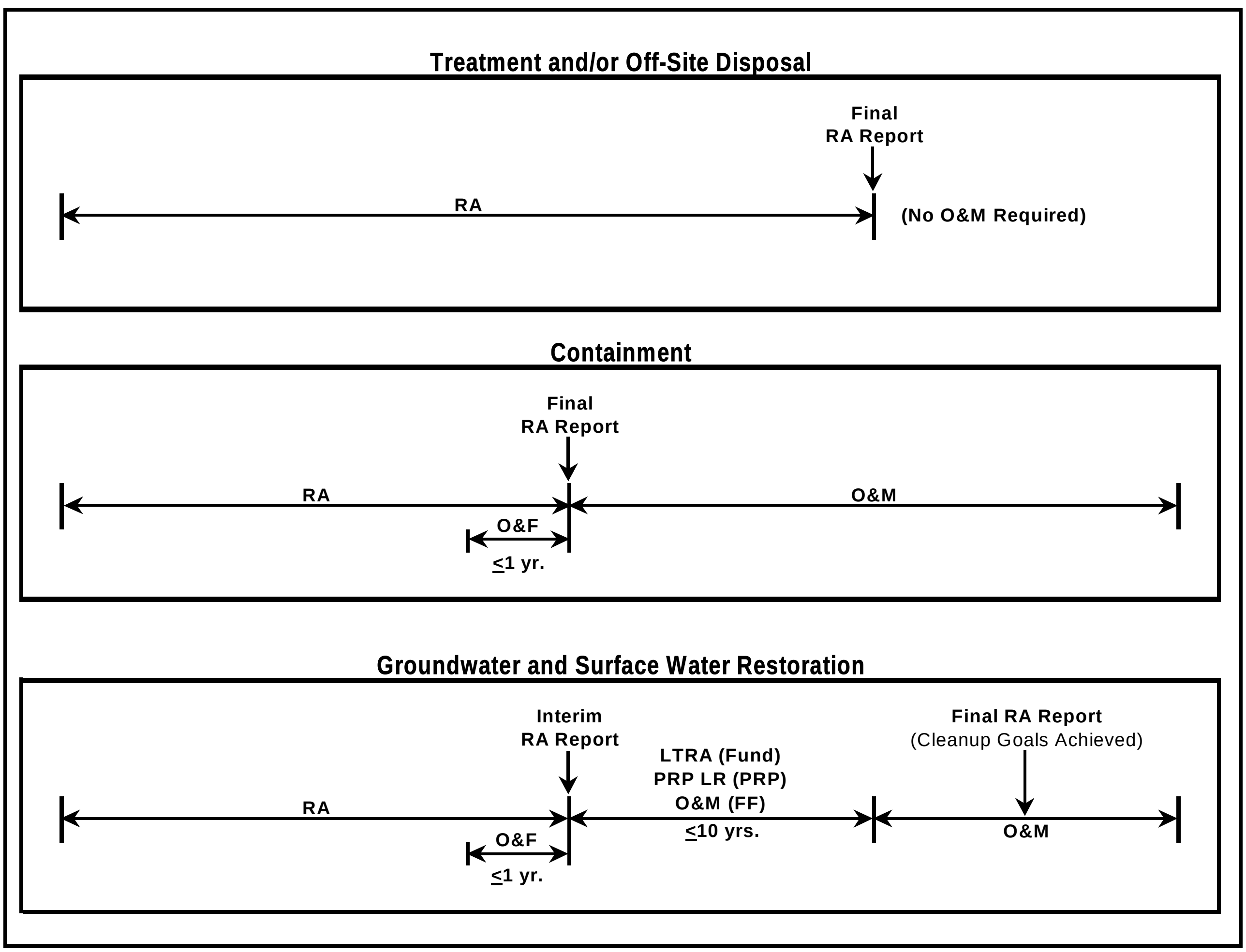
[2] The RI/FS can be performed for the site as a whole, or for a particular portion of the site. The NCP defines an OU as a "discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of a release, or pathway of exposure" (NCP §300.5). Hence, an OU can be a certain geographic portion of a site or a specific environmental medium at the site (e.g., groundwater or soil). The OU may also consist of a comprehensive but temporary remedy (e.g., a temporary cap over a site) that provides interim protection of human health and the environment before final remediation. The cleanup of a site can be divided into a number of OUs, depending on the complexity of the problems associated with the site.

[3] For pre-SARA sites, the selected remedy may be detailed in other reports (e.g., a consent decree or an administrative order).

d. Remedial Design. Plans, specifications, and other documents necessary to construct or implement the remedy are developed during remedial design (RD), an engineering phase that precedes the RA. The specifications are based upon the detailed descriptions of the selected remedy and the remediation/cleanup criteria provided in the ROD.

e. Remedial Action. The RA is the implementation of the selected remedy from the ROD and the RD. RA activities must conform to the remedy set forth in the ROD and other post-ROD decision documents (e.g., ROD amendments, explanation of significant differences). The remedial action includes the completion of an operational and functional (O&F) period (Paragraph 2-2.a), if necessary, followed by any long-term response action (LTRA) for groundwater or surface water remedies (Paragraph 2-2.a), prior to long term operation and maintenance (O&M) of the remedy.

Exhibit 2-2
Example Pipeline Scenarios



f. Operation and Maintenance. Operation and maintenance (O&M) are the activities required to maintain the effectiveness or the integrity of a remedy. O&M is dependent on the implemented remedy. O&M may not be necessary, may only be required for a defined timeframe, or may be required to be performed indefinitely.[4] For remedies that require active on-site treatment, remedial system evaluation or optimization is an important component of O&M.[5] Except for Fund-financed groundwater or surface water restoration actions covered under NCP §300.435(f)(4), O&M measures are initiated after the remedy has achieved the remediation objectives and cleanup goals listed in the ROD, and is operational and functional (Paragraph 2-2.a). O&M starts when the RA is complete and the State or the PRP(s) assume responsibility for all activities necessary to operate and/or maintain the long-term effectiveness or integrity of the actions selected in the ROD. In the case of Fund-financed measures to restore groundwater or surface waters, that extend beyond the ten-year long-term RA period (Paragraph 2-2.b), O&M is required to continue the operation of such measures until the cleanup goals are achieved.

2-2. <u>Remedial Action Process</u>. Besides the RA and O&M phases, the RA process typically includes the operation and functional period, long-term response, cleanup goals achieved milestone, and five-year reviews. Exhibit 2-2 provides three different pipeline scenarios to help illustrate when these periods occur in relation to preparation of the RA report. The following paragraphs provide a brief description of each phase or milestone.

a. Operational and Functional

(1) Operational and functional (O&F) activities are conducted after the RA has been constructed to ensure that it is operating as designed and functioning properly. The O&F period is part of the RA and occurs during the last year of the RA. The NCP provides for a maximum timeframe of one year for performing O&F activities, though EPA may extend the one-year period, as appropriate. O&F determinations are made for containment (all media), groundwater restoration and surface water restoration remedies.[6] Monitored natural attenuation remedies do not go through an O&F determination.

(2) A remedy becomes O&F either one year after O&F start, or when the remedy has been determined, concurrently by EPA and the State agency, to be functioning properly and performing as designed, whichever occurs first (40 CFR 300.435). O&F is considered to be complete on the date that the designated Regional official approves, in writing, the interim RA report (for sites with groundwater or surface water restoration remedies) or final RA report. This

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[4] Examples of remedies where O&M may have an indefinite period of performance are sites where waste is contained on-site and the integrity of the cap must be maintained or sites where institutional controls must be maintained.

[5] Additional information on remedial system evaluation or optimization is available on the web at *http://www.frtr.gov/optimization/*.

[6] Formal O&F determinations are made primarily for Fund-financed projects because the O&F milestone governs when O&M or Long-Term RA (LTRA) begins under State authority. Federal facilities-lead projects go through determinations known as "operating properly and successfully."

report should not be approved until the determination has been made through an inspection that the remedy is, in fact, O&F (Paragraph 2-3).

b. Long-Term Response.

(1) Long-term response action (LTRA) and PRP long-term response (LR) are sub-actions of O&M used to track and assure continued Federal funding for the operation of groundwater or surface water restoration remedies.[7] LTRA is defined as the Fund-financed operation of groundwater and surface water restoration measures, including monitored natural attenuation, for up to the first ten years of operation. LTRA is complete after ten years, after a technical impracticability determination is made, or after cleanup goals are achieved and documented in a final RA report, whichever occurs first. LTRA transitions to traditional O&M if cleanup goals are not achieved, or if continued monitoring is required, after ten years have elapsed.

(2) In the past, the term LTRA has been used to describe PRP-lead groundwater and surface water restoration measures, including monitored natural attenuation. However, PRP-lead groundwater and surface water restoration measures, including monitored natural attenuation, are covered by a separate action, PRP LR. Because PRP LR is a specific type of O&M, the ten-year timeframe does not apply. PRP LR is complete after a technical impracticability determination is made, or cleanup goals are achieved and documented in a final RA report, whichever occurs first.

c. Cleanup Goals Achieved. Usually preceded by the interim RA report, this milestone signifies when cleanup goals are achieved for groundwater and surface water restoration, including monitored natural attenuation. “Cleanup goals achieved” is officially accomplished once the final RA report is approved in writing.

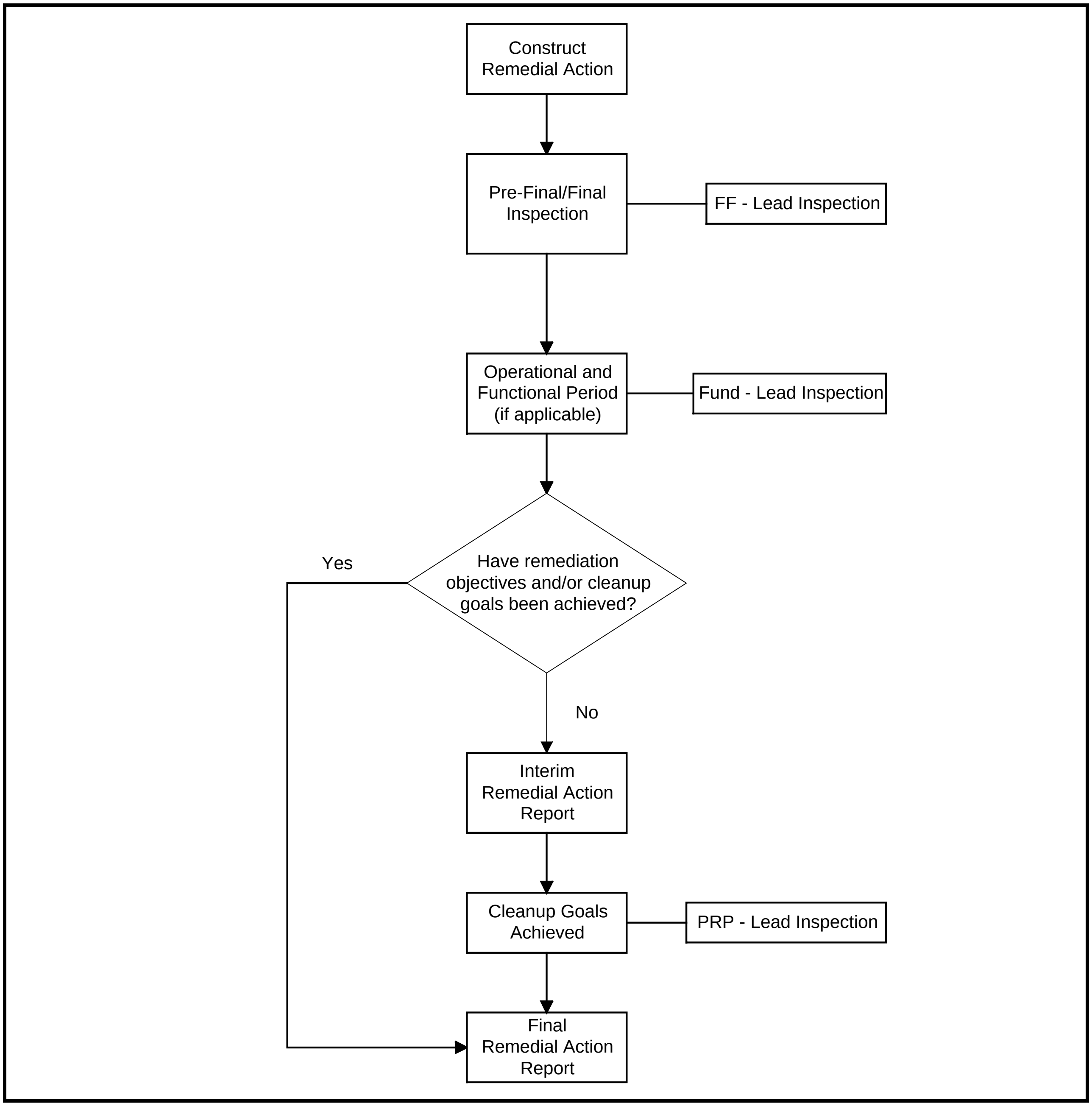
d. Five-Year Reviews. If there are any hazardous substances, pollutants, or contaminants remaining at the site above levels that do not allow for unlimited use and unrestricted exposure, EPA is required to conduct a review of the RA at least once every five years to assure that human health and the environment are being protected. CERCLA §121(c) and NCP §300.430(f)(5)(iii)(C) provide the legal bases for conducting five-year reviews. Generally, five-year reviews may be discontinued when no hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.

2-3. Remedial Action Completion. The RA for an OU is complete after the remedy is determined to be O&F (if applicable), the remediation objectives and/or cleanup goals stated in

[7] LTRA and PRP LR apply to groundwater and surface water restoration measures only, including monitored natural attenuation. These terms do not apply to groundwater and surface water restoration measures conducted under other leads; groundwater or surface water containment measures; groundwater or surface water measures initiated for the primary purpose of providing a safe drinking water supply; or groundwater monitoring. Federal facilities-lead sites do not use LTRA or PRP LR. Instead, groundwater and surface water restoration measures go from RA directly to O&M at these sites.

the ROD are achieved, and the designated Regional official has approved the interim or final RA report. Exhibit 2-3 illustrates the remedial action completion process.

Exhibit 2-3
Remedial Action Completion Process



a. Inspection Requirements.

(1) General. With any RA, regardless of lead or contracting party, the standard practice is to conduct contract pre-final and final inspections prior to RA completion. These

inspections are conducted to determine whether the construction is complete in accordance with the contract design and specifications. The inspections are generally held between the contracting party and the construction contractor, although others can be invited. If all the items observed during the contract pre-final inspection are corrected or are considered insignificant, the contract pre-final inspection may automatically serve as the contract final inspection. Otherwise, a contract final inspection will be conducted later by the contracting party to determine if these items have been corrected and completed in accordance with the RD plans and specifications. In addition to the pre-final and final inspections, other inspections may be required prior to completion of the RA. These include Fund-lead, PRP-lead, and Federal facility (FF)-lead inspections as described below.

(2) Fund – Lead. The NCP requires an additional set of inspections at Fund-financed sites that will undergo LTRA and/or O&M. During this set of inspections, EPA and the State concurrently determine the end of the O&F period. After an O&F determination is made, the remedy enters LTRA or O&M. If convenient, these inspections may be conducted concurrently with the contract pre-final or final inspection.

(3) PRP – Lead. For PRP-lead sites, the Revised Model CERCLA RD/RA Consent Decree (Federal Register, Vol. 60, No. 145, pp. 38817-38837, July 28, 1995) requires a pre-certification inspection upon completion of the RA. This inspection, which involves the PRP(s), EPA, and the State, is intended to determine if the RA is fully complete and if the remediation objectives/cleanup goals are attained. After the pre-certification inspection, the PRPs are also required to submit a written report, for EPA approval, stating that the RA is complete in full compliance with the requirements of the Consent Decree. If it contains the proper information, this report can serve as the RA report for the OU. For groundwater and surface water restoration remedies, where an interim RA report is appropriate, EPA may require the preparation of a separate (interim) RA report for groundwater or surface water, since it is not normally required in the Consent Decree.

(4) FF – Lead. Federal facility agreements (FFAs) generally require an additional set of inspections to determine that all aspects of the remedy have been implemented in accordance with applicable enforcement documents and the ROD. Participants include the EPA, Federal facility, oversight contractor, and the State. These inspections may be conducted concurrently with either of the pre-final or final inspections described above.

b. Remedial Action Reporting. When the RA for an operable unit is complete, the RA report is prepared. There are two basic types of RA reports, interim and final. An interim RA report is completed only for RAs that include groundwater or surface water restoration remedies, including monitored natural attenuation. Interim reports are used because of the extended duration between the completion of the treatment system construction (or the ROD signature, in the case of monitored natural attenuation) and the achievement of the cleanup goals. A final RA report is complete when the remediation objectives/cleanup goals are achieved. More detailed information on preparation, timing, distribution, approval, and review of RA reports is provided in Chapter 3.

CHAPTER 3
REPORTING CRITERIA

3-1. Preparation. The party most familiar with the RD, the construction efforts, and the associated project costs, should prepare the RA report. This familiarity will provide the best opportunity to discuss the successes, difficulties, and lessons learned during the project. The EPA RPM and contractor for the RA (e.g., PRP, U.S. Army Corps of Engineers, State or EPA contractor) are typically the parties most familiar with the RA. While the EPA RPM can and sometimes does prepare the RA report, the contractor is usually tasked with that effort.

3-2. Timing. For most OUs, the RA report should be prepared and submitted to the EPA region (Region) or appropriate regulatory authority for approval within 90 days after the contract final inspection of the completed construction.[1] At OUs where LTRA is being performed, an interim RA report should be prepared once the remedy is constructed (within 90 days after the final inspection). The interim RA report must then be amended and finalized once the RA cleanup goals specified in the ROD are achieved. An interim RA report is required because of the extended period of time that may elapse between the completion of construction and achievement of cleanup goals. Where actual costs are not known at the time of report preparation (e.g., pending claims, change orders), estimated costs may be used (Chapter 6).

3-3. Distribution.

a. Once the Region or appropriate regulatory authority has approved the RA report, either interim or final, depending on the remedy, the original report is retained in the Regional site file, and an approved copy should be returned to the report preparer. Upon completion of the RA report, the Region or appropriate regulatory authority is required to notify the appropriate Natural Resource Trustees listed in the Regional Contingency Plans regarding the completion of the RA. The Region or appropriate regulatory authority will provide a copy of the approved RA report to the Trustees within one week of the report's approval.

b. For projects in which the USACE is involved, a copy of the RA report shall be furnished to HQ USACE and the USACE HTRW Center of Expertise (CX). Mailing addresses are provided in Appendix D.

3-4. Approval.

a. For a given site or OU, the RA is considered to be complete once the designated EPA Regional official has approved the interim or final RA report in writing. An interim RA report is completed only for RAs that include groundwater or surface water restoration remedies (including monitored natural attenuation). Interim reports are used because of the extended period of time that typically transpires between the completion of the treatment system construction (or the ROD signature, in the case of monitored natural attenuation) and the

[1] For PRP-lead sites, the RA report is due within 90 days after the official determination has been made that the remediation objectives/cleanup goals have been achieved.

achievement of the cleanup goals. A final RA report is complete once the remediation objectives/cleanup goals are achieved.

b. Criteria required for EPA approval of an interim RA report include:

(1) The remedy to reduce contaminant concentrations and achieve the cleanup goals, including groundwater or surface water restoration, with active treatment or natural attenuation, is installed;

(2) For active treatment, the construction of the treatment system is complete and the system is operating as intended (i.e., the remedy is determined to be O&F at Fund-financed sites);

(3) For monitored natural attenuation, any necessary RA components, such as monitoring wells, are constructed;

(4) If the OU addresses media other than groundwater, construction activities are complete and RA objectives specified in the ROD are achieved for these components;

(5) A final inspection is conducted;

(6) Institutional controls, if applicable, are in place; and

(7) The interim RA report includes the information described in Chapter 4 of this guide.

c. Criteria required for the approval of a final RA report include:

(1) All construction activities are complete, including site restoration and demobilization;

(2) All RA objectives specified in the ROD, including those for groundwater and surface water (if applicable), are achieved;

(3) A final inspection is conducted;

(4) Institutional or engineering controls, such as containment (if applicable), are in place (i.e., the remedy is determined to be O&F at a Fund-financed site); and

(5) The final RA report includes the information described in Chapter 4 of this guide.

d. When an interim RA report has already been prepared, the interim RA report may simply be amended to create the final RA report. The amendment would add information on activities that occurred after the interim RA report was completed, including a final actual cost breakdown.

3-5. Review. Prior to submittal of the RA report, it should be reviewed to ensure that it contains the necessary information. Exhibit 3-1 provides a checklist that summarizes the recommended content of the RA report. Each component listed in the checklist is further described in Chapter 4, including examples.

Exhibit 3-1

Remedial Action Report Checklist

SECTION	COMPONENT
I. Introduction	♦ Include a brief description of the location, size, environmental setting, and operational history of the site. ♦ Describe the operations and waste management practices that contributed to contamination of the site. ♦ Describe the regulatory and enforcement history of the site. ♦ Describe the major findings and results of site investigation activities. ♦ Describe prior removal and remedial activities at the site. ♦ Describe the OUs designated at the site and introduce the OU for which the RA report applies.
II. Operable Unit Background	♦ Summarize requirements specified in the ROD for the OU. Include information on the remediation objectives/cleanup goals, institutional controls, monitoring requirements, operation and maintenance requirements, and other parameters applicable to the design, construction, operation, and performance of the RA. ♦ Provide additional information regarding the basis for determining the remediation objectives/cleanup goals for the OU, including information on planned future land use. ♦ Summarize the remedial design, including any significant regulatory or technical considerations or events occurring during the design. ♦ Identify and briefly discuss any ROD amendments, explanation of significant differences, or technical impracticability waivers.
III. Construction Activities	♦ Provide a step-by-step description of the major activities undertaken to construct and implement the RA (e.g., mobilization and site preparatory work; construction of the treatment system; associated site work, such as fencing and surface water collection and control; system operation and monitoring; and sampling activities). ♦ If a treatment technology was used, refer to Appendix A for site conditions, matrix characteristics and/or operating parameters of the system.

Exhibit 3-1, cont.

Remedial Action Report Checklist

SECTION	COMPONENT
IV. Chronology of Events	♦ Provide a tabular summary that lists the major events for the OU, and associated dates of those events, starting with the ROD signature. ♦ Include significant milestones and dates, such as, remedial design submittal and approval; ROD amendments; mobilization and construction of the remedy; significant operational events such as treatment system/application start-up, monitoring and sampling events, system modifications, operational down time, variances or non-compliance situations, and final shut-down or cessation of operations; final sampling and confirmation-of-performance results; required inspections; demobilization; and completion or startup of post-RA operation & maintenance activities. ♦ If an operational and functional (O&F) period applies, indicate the start and end dates of the O&F period. ♦ If preparing an interim RA report, indicate when cleanup goals are projected to be achieved for the ground or surface water restoration.
V. Performance Standards and Construction Quality Control	♦ Describe the overall performance of the technology in terms of comparison to remediation objectives/cleanup goals. ♦ For treatment remedies, identify the quantity of material treated, the strategy used for collecting and analyzing samples, and the overall results from the sampling and analysis effort. ♦ Provide an explanation of the approved construction quality assurance and construction quality control requirements or cite the appropriate reference for this material. Explain any substantial problems or deviations. ♦ Provide an assessment of the performance data quality, including the overall quality of the analytical data, with a brief discussion of quality assurance and quality control (QA/QC) procedures followed, use of a quality assurance project plan (QAPP), comparison of analytical data with data quality objectives (DQOs). ♦ For PRP-funded projects, discuss the government's oversight activities and results with regard to analytical data quality.
VI. Final Inspection and Certifications	♦ Report the results of the various RA construction inspections, and identify noted deficiencies. ♦ Briefly describe adherence to health and safety requirements. Explain any substantial problems or deviations. ♦ If implemented, summarize details of institutional controls (e.g., type, who will maintain, who will enforce). ♦ For PRP-lead, describe results of precertification inspection. ♦ If applicable, certify that the remedy is operational and functional, along with the date this was achieved.

Exhibit 3-1, cont.

Remedial Action Report Checklist

SECTION	COMPONENT
VII. Operation & Maintenance Activities	♦ Describe the general activities for post-construction operation and maintenance, such as monitoring, site maintenance, and closure activities. ♦ Identify potential problems or concerns with such activities. ♦ Note results of any optimization efforts during O&M. ♦ If preparing an interim RA report, describe the future groundwater or surface water restoration activities to meet cleanup goals.
VIII. Summary of Project Costs	♦ Present the total costs incurred for the remedial action. Identify costs as capital, O&M, or periodic costs, either RA or post-RA, as applicable (e.g., RA capital costs, RA operating costs, post-RA O&M costs). ♦ The reporting of project costs is required for government-financed projects and should be provided whenever possible for PRP-lead projects. If the project is PRP-lead, a summary of government oversight costs for the RD and RA should be included. ♦ Indicate the year(s) in which costs were incurred. ♦ If actual costs are not available, use estimated costs. ♦ Escalate costs estimated in the ROD to the same dollar basis year and compare the total project costs, actual or estimated, to the ROD estimate. If outside the range of –30 to +50 percent, explain the differences. Provide the index or rate used for the escalation.
IX. Observations and Lessons Learned	♦ Provide site-specific observations and lessons learned from the project, highlighting successes and problems encountered and how resolved.
X. Operable Unit Contact Information	♦ Provide contact information (names, addresses, phone numbers, and contract/reference data) for the major design and remediation contractors and subcontractors, oversight contractors, and the respective remedial project manager (RPM) and project managers for the government and the PRPs, as applicable.
XI. References	♦ Provide a list of references used to develop the RA report (e.g., ROD, RD documents, RA correspondence, as-built drawings).
Appendix A. Cost and Performance Factors	♦ List values and measurement procedures for factors affecting cost and performance of treatment technologies used in the remedy, including site conditions, matrix characteristics, and operating parameters.
Appendix B. Project Costs	♦ Provide a breakdown of the actual RA capital, operating, and/or periodic costs. ♦ Provide a breakdown of the future projected O&M and/or periodic costs.

CHAPTER 4
REPORT COMPONENTS

4-1. General.

a. This chapter describes the components of the recommended format for the RA report and details the information that should be included in each component. The components are divided into the following:

(1) Abstract

(2) Section 1: Introduction

(3) Section 2: Operable Unit Background

(4) Section 3: Construction Activities

(5) Section 4: Chronology of Events

(6) Section 5: Performance Standards and Construction Quality Control

(7) Section 6: Final Inspection and Certifications

(8) Section 7: Operation & Maintenance Activities

(9) Section 8: Summary of Project Costs

(10) Section 9: Observations and Lessons Learned

(11) Section 10: Operable Unit Contact Information

(12) Section 11: References

(13) Appendix A: Cost and Performance Factors

(14) Appendix B: Project Costs

b. The RA report should be straightforward and easily understood, using consistent CERCLA terminology where applicable. The report length should generally not exceed twenty pages, excluding appendices, relying on brief descriptions for each report component. Tables and figures that support the report may be inserted within the text, at the end of each section, or collectively at the end of the report. An example RA report abstract is shown in Exhibit 4-1. Examples for other report components are provided in the following chapter sections that describe each component.

Exhibit 4-1
Example Abstract

Site Name and Operable Unit:	U Creosote Superfund Site, Operable Unit 2
Location:	Live Oak, Florida
Regulatory Oversight:	U.S. Environmental Protection Agency Region IV Florida Department of Environmental Regulation
Contractor Oversight:	U.S. Army Corps of Engineers, Jacksonville District
Remedial Action Contractor:	Cleanup, Inc., Cleantown, FL
Waste Source:	Sludge and soil contaminated with lumber treatment chemicals (including creosote and small amounts of pentachlorophenol)
Contaminants:	Polycylic aromatic hydrocarbons (PAHs) designated as total carcinogenic indicator chemicals (TCIC), including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene Pentachlorophenol (PCP)
Technology:	Land Treatment: ♦ Contaminated soil with TCIC contractions <5,000 mg/kg was excavated and placed in 4- to 12-inch-thick lifts and inoculated with PAH-degrading microorganisms. ♦ Composite samples were collected from subplots each quarter, until TCIC concentrations were detected at less than 100 mg/kg. ♦ Upon confirmation that cleanup goals had been met, the site was backfilled with clean soil and revegetated. ♦ Groundwater at the site is to be monitored for five years.
Cleanup Type:	Full-Scale
Purpose/Significance of Application:	Land treatment designed to reduce TCIC concentrations to 100 mg/kg within two years of initial placement and inoculation.
Type/Quantity of Media Treated:	8,100 cubic yards of contaminated soil were land treated
Period of Operation:	Land treatment: 1/19/97 to 7/24/98 Groundwater monitoring: Ongoing
Regulatory Requirements/ Cleanup Goals:	Soils >100 mg/kg, but <5,000 mg/kg TCICs to be land treated to 100 mg/kg. Remediation objectives to be met within two years or progress shown toward meeting objectives. If this could not be shown, alternative measures would be considered. Five years of groundwater monitoring to be implemented upon completion of construction.
Results:	Sampling conducted in June 1998 indicated that TCIC concentrations were <100 mg/kg, ranging from 23 to 92 mg/kg in the eight subplots. Cleanup goals were attained within 18 months of land treatment startup.

Exhibit 4-1, cont.
Example Abstract

Costs:	Total actual cost = $435,523 with RA capital costs of $303,026 and RA operating costs of $132,497. Total estimated remaining O&M cost = $21,000 for five years of groundwater monitoring. The technology-specific unit cost of land treatment was calculated at $33.73 per cubic yard.
Description:	From 1948 to 1986, the ABC company operated the U Creosote site as a lumber treatment facility. Lumber treatment processes included the pressure-treatment of lumber products. Small rail cars were used to move lumber to two treatment cylinders. A mixture of either creosote and water or PCP and petroleum was used to treat the lumber. The treated lumber was dried on racks over bare soil and stored in an area north of the treatment cylinders. The results of a remedial investigation/feasibility study (RI/FS) conducted at the site between 1992 and 1996 confirmed that soils and sediments in the lagoon and drainage ditch were contaminated with polycyclic aromatic hydrocarbons (PAH). During the RI/FS, EPA and the PRPs agreed to address the site as two operable units (OUs). OU 1 includes the lagoon and former plant facility, which has been addressed separately. The record of decision for OU 2 was signed on March 8, 1996. During land treatment, the soil for each of three lifts was placed 4 to 12 inches thick in the land treatment area and inoculated with PAH-degrading microorganisms. An inoculum was sprayed on the soil and the land treatment area was cultivated once every two weeks. An irrigation system was used to maintain a 10-percent soil moisture content. The concentration of microorganisms in the soils was found to be adequate to support biological activity, and no inoculum was applied for the second or third lift. Additionally, the total number of lifts applied to each subplot varied because several of the half-acre areas exceeded the TCIC concentrations of 100 mg/kg. Subsequently, no additional soil was placed in those subplots until the analytical results indicated less than 100 mg/kg. On October 17, 1998, the PRPs provided a written report that the remedial action has been fully performed and the performance standards of the consent decree have been attained. As specified in the ROD, the PRPs will continue semiannual monitoring of groundwater through 2002 to confirm that groundwater will not be adversely impacted by the land treatment activities.

4-2. <u>Introduction</u>.

a. The introduction should include a brief description of the location, size, environmental setting, and history of the site. The site history should describe the operations and waste management practices that contributed to the contamination of the site, and the regulatory and enforcement activities that have occurred. The introduction should also discuss the major findings and results of SI and RI activities. Any prior removal and remedial activities that have occurred at the site should be described. Any other OUs that have been designated at the site should be discussed and the OU addressed by the RA report should be introduced. An example introduction is provided in Exhibit 4-2.

b. Because the introduction provides background information on the entire site, most of it could also be used as the introduction of the RA report for other OUs at the site. The information for the introduction can be taken from reports prior to the RD or RA, such as the RI/FS or ROD.

Exhibit 4-2
Example Introduction (Section 1)

The U Creosote Superfund Site is located approximately two miles from the City of Live Oak, Suwanee County, Florida, at the intersection of Sawmill Road and Goldkist Road. Homes, businesses, light industry, a trailer park, a private airport, and a county storage yard are located within one-half mile of the site. Approximately 450 people live in the trailer park. Sinkholes and public and private wells lie within two miles of the site.

From 1948 to 1986, the ABC company operated the U Creosote site as a lumber treatment facility. Lumber treatment processes included the pressure-treatment of lumber products, mainly with creosote and occasionally with pentachlorophenol (PCP). Small rail cars were used to move lumber to two treatment cylinders. A mixture of either creosote and water or PCP and petroleum was used to treat the lumber. The treated lumber was dried on racks over bare soil and stored in an area north of the treatment cylinders.

Wastewater from the treatment cylinders was discharged to an oil-water separator. The creosote recovered from the oil-water separator was sent to a storage tank for reuse. If the creosote was determined to be off specification, it was sent to a spent creosote storage tank and properly disposed of at an off-site location at a later date. Wastewater from the oil-water separator discharged through a culvert and a drainage ditch to an unlined three-acre lagoon located in the southwest corner of the site.

In 1989, a former owner of the facility notified Region 4 of the U.S. Environmental Protection Agency (EPA) that hazardous materials may have been handled at the site. In response, the Florida Department of Environmental Regulation (FDER) conducted sampling at the site in July 1990. The results showed that soil and sludge in the area of the treatment cylinders were contaminated with a number of organic compounds and that the treatment cylinders contained small amounts of solidified creosote and PCP. In addition, creosote was found in the lagoon and the storage tanks. No contamination was detected in the aquifer underlying the site. EPA proposed in December 1990 that the site be placed on the National Priorities List (NPL). The listing of the site became final in September 1991.

The potentially responsible parties (PRP) conducted a remedial investigation and a feasibility study (RI/FS) at the site between 1992 and 1996 under the terms of a Federal administrative order on consent (AOC). Testing during that time confirmed that soils and sediments in the lagoon and drainage ditch were contaminated with polycyclic aromatic hydrocarbons (PAH). During the RI/FS, EPA and the PRPs agreed to address the site as two operable units (OU), OU1 and OU2.

OU1 included the lagoon and the former plant facility. Cleanup activities were completed in March 1996, under a Record of Decision (ROD) signed on July 25, 1995. The lagoon was drained, contaminated sludge and sediment was excavated, and wastewater was treated and discharged to a publicly owned wastewater treatment facility. Highly contaminated sludge and soil were solidified on site.

A ROD for OU2 was signed March 8, 1996, which is the subject of this report.

4-3. Operable Unit Background. This section should summarize the requirements specified in the ROD for the subject OU. It should include information on the cleanup goals, institutional controls, monitoring requirements, O&M requirements, and other parameters applicable to the design, construction, operation, and performance of the RA. Additional information regarding the basis for establishing the cleanup goals/remediation objectives, including planned future land use, should be provided. A summary of the RD, including any significant regulatory or technical considerations or events occurring during the preparation of the RD, should also be included in this section. Any ROD amendments, explanation of significant differences, or technical impracticability waivers should also be identified and briefly discussed. An example background section is provided in Exhibit 4-3.

Exhibit 4-3
Example Operable Unit Background (Section 2)

The remedy described in the ROD for OU2 included:

- On-site biodegradation of remaining, less-severely contaminated soils in a land treatment area constructed with a liner, internal drainage, and spray irrigation system;
- Activities necessary to the proper functioning of the land treatment process;
- After treatment, covering the land treatment area with clean fill and re-vegetating; and
- Five years of groundwater monitoring to verify that it remains uncontaminated.

The remediation objectives in the ROD were: Within two years from initial seeding, the land treatment process must reduce the concentration of TCIC to 100 mg/kg throughout the volume of the material treated. The goals were based upon a risk assessment that focused on attaining at least a 1×10^{-6} risk for ingestion of contaminated soil by a child. The risk assessment assumed a future industrial land use scenario, with no institutional controls. Remediation objectives were described by the total concentration of six carcinogenic indicator constituents of creosote -- benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, dibenzo(a, h)anthracene, and indeno(1,2,3-c,d)pyrene – referred to as total carcinogenic indicator chemicals (TCIC). EPA selected the six of the approximately two hundred compounds that make up creosote because of their concentrations in sludge and soil at the site and their carcinogenic nature. The concentrations of TCIC in the soil to be treated ranged from 100 to 208 mg/kg.

The September 15, 1996, ROD amendment included:

- Soils contaminated at levels exceeding 100 mg/kg, but less than 5,000 mg/kg TCICs, were to be biodegraded in the on-site land treatment area.
- Soils found contaminated at levels exceeding 5,000 mg/kg TCICs were to be removed, stabilized, and disposed of at an EPA-approved hazardous waste disposal facility along with the solidified, OU 1 waste (7,500 yd^3).
- If the land treatment process did not attain the remediation objectives for the TCIC within two years, but quarterly monitoring showed substantial progress toward meeting the remediation objectives, EPA would consider extending the treatment period. However, if substantial progress could not be identified, EPA would consider alternative means of addressing the contaminated soils, such as capping, removal, incineration, solidification, or vitrification.
- Groundwater monitoring would begin upon completion of construction of the land treatment area.

Based on the original ROD and the ROD amendment, the remedial design was prepared for construction of the remedy. The design was completed in five months and approved by EPA September 15, 1996, for implementation of the remedial action.

4-4. Construction Activities. This section should provide a step-by-step description of the activities undertaken to construct and implement the RA (e.g., mobilization and site preparatory work; construction of the treatment system; associated site work, such as fencing and surface water collection and control; system operation and monitoring; and sampling activities). If a treatment technology was used, reference should be made to the appropriate appendix that reports factors affecting cost and performance of the system (e.g., site conditions, matrix characteristics, and operating parameters). An example construction activities section is provided in Exhibit 4-4.

Exhibit 4-4
Example Construction Activities (Section 3)

Site Preparation

Site preparation activities included clearing, grubbing, and grading the land where the land treatment area was to be constructed; building a drainage swale around the land treatment area; preparing a temporary, central soil stockpile area consisting of several lined cells; and installing a perimeter fence with signs warning against exposure to hazardous material. Approximately four acres were cleared. An estimated 200 cubic yards of contaminated soil found to contain less than 5,000 mg/kg TCICs were excavated during the site preparation activities and stored in the central stockpile area along with previously excavated, contaminated soil.

Off-Site Disposal of the Solidified, Operable Unit 1 Waste

To dispose of the 7,500 cubic yards of solidified OU 1 waste, a suitable receiving facility in Emelle, Alabama, operated by Chemical Waste Management, Inc. (CWM), was identified. The waste was shipped off-site to the facility in Emelle on December 1, 1996.

Construction of the Land Treatment System

A clay layer ranging from one to three feet in thickness was installed throughout the four-acre land treatment area. The clay was taken from a borrow pit located elsewhere on the site. The borrow pit was shaped and used as a 750,000-gallon retention pond for collecting water and leachate from the land treatment area. Compacted clay berms were placed around the land treatment area and around the soil stockpile area. Swales were installed outside the treatment area to intercept and redirect run-on.

The land treatment area was prepared with a one percent slope to the northwest corner, where the subsurface drainage system drained under the berm into a gravel-lined swale that led to the retention pond. The drainage system consisted of 12-inch-wide, flat, perforated pipe laterals, spaced every 50 feet in an east-to-west direction. The pipes connected to a south-to-north drainage trench containing cylindrical, perforated piping sloping to a sump in the northwest corner of the land treatment area. The entire subsurface drainage system was covered with a minimum of six inches of clean, sorted sand. Finally, a portable irrigation system, delivering water at 0.5 inches per hour to an area 70 feet in diameter, was installed at the retention pond, which recirculated the collected water and sprayed the water over the land treatment area.

System Operation

Land treatment was performed in three lifts, with a total of 8,100 yd^3 of soil treated: 3,300 yd^3 (Lift 1); 3,000 yd^3 (Lift 2); and 1,800 yd^3 (Lift 3). For site management and sampling purposes, the land treatment area was divided into eight half-acre, rectangular subplots. A composite sample was collected from each subplot each quarter, until the concentration of TCICs in the soil in the subplot was less than 100 mg/kg. An additional lift of soil from the stockpile area then was placed in the subplot. The process was repeated until all of the stockpiled soil had been placed in the land treatment area.

Exhibit 4-4, cont.
Example Construction Activities (Section 3)

In general, the soil for each lift was placed 4 to 12 inches thick in the land treatment area and inoculated with PAH-degrading microorganisms. The inoculum, sprayed on the soil, was developed by growing seed cultures in mobile, on-site reactor tanks equipped with aeration and mixing equipment. The land treatment area was cultivated once every two weeks. An irrigation system was used to maintain a 10-percent soil moisture content. The concentration of microorganisms in the soils at the land treatment area was found to be adequate to support biological activity, and no inoculum was applied for the second or third lift. Additionally, the total number of lifts applied to each subplot varied because several of the half-acre areas exceeded the TCIC concentrations of 100 mg/kg. Subsequently, no additional soil was placed in those subplots until the analytical results indicated less than 100 mg/kg.

Appendix A reports matrix characteristics and operating parameters of the land treatment system.

Approximately 50 cubic yards of construction debris were removed from the soil and buried on the site. After validation of the final sampling results and determination that the remediation objectives had been met, the site was backfilled with clean soil and seeded on September 1, 1998.

4-5. Chronology of Events. This section should provide a tabular summary that lists the major events for the OU, and associated dates of those events, starting with the ROD signature. The table should include significant milestones and dates, including: RD submittal and approval; ROD amendments; mobilization and construction of the remedy; treatment system/application start-up; monitoring and sampling events; system modifications; operational down time; variances or non-compliance situations; date of final shut-down or cessation of operations; final sampling and confirmation-of-performance results; required inspections; demobilization; and RA completion or startup of post-RA O&M activities. If an O&F period applies, indicate the start and end dates. For interim RA reports, indicate when cleanup goals are estimated to be achieved. An example chronology is provided in Exhibit 4-5.

Exhibit 4-5
Example Chronology of Events (Section 4)

Date	Event
March 8, 1996	ROD for OU2 signed.
August 3, 1996	Remedial Design (RD) submitted.
September 15, 1996	RD approved; ROD amendment signed.
September 29, 1996	RA contract awarded.
October 3, 1996	Construction of the land treatment area began, including excavation of contaminated soil..
December 1, 1996	Solidified waste from OU1 transported and disposed of off-site.
December 12, 1996	PRPs, EPA, and the State conduct pre-final inspection of the land treatment area.
January 12, 1997	PRPs, EPA, and the State conduct final inspection of the land treatment area.
January 19, 1997	Operation of land treatment area begun; first lift of soil applied to treatment subplots; sampling of soil in treatment plots begun.

Exhibit 4-5, cont.
Example Chronology of Events (Section 4)

Date	Event
January 20, 1997	Semiannual groundwater monitoring initiated .
June 12, 1997	Preliminary Close Out Report for site signed for site construction completion.
September 15, 1997	Second lift of soil applied to treatment subplots.
March 14, 1998	Third lift of soil applied to treatment subplots.
June 28, 1998	Final sampling of soil in treatment subplots and in other designated site areas conducted.
July 24, 1998	Final soil sampling results validated; remediation objectives achieved.
September 1, 1998	Land treatment area demobilized and re-vegetated.
September 22, 1998	PRPs, EPA, and the State conduct pre-certification inspection of the completed remedial action.
Ongoing	Semiannual groundwater monitoring. Expected to continue through 2002.

4-6. <u>Performance Standards and Construction Quality Control</u>.

a. This section should describe the overall performance of the remedial technology in terms of a comparison to cleanup goals/remediation objectives. For treatment remedies, this section should identify the quantity of material treated, the strategy used for collecting and analyzing samples, and the overall results from the sampling and analysis effort. An explanation of the approved construction quality assurance (QA) and quality control (QC) requirements, or citations for the appropriate references, should be provided. An explanation of any substantial problems or deviations should be included.[1] An assessment of the performance data quality and of the overall analytical data quality should be provided, including a brief discussion of the QA/QC procedures followed, the quality assurance project plan (QAPP) used, and the data quality objectives (DQOs) to which the analytical data were compared. For PRP-lead projects, a discussion should be provided of EPA's oversight activities and results with regard to analytical data quality. An example section is provided in Exhibit 4-6.

b. Specific topics to consider for this section include sample frequency and protocol, concentrations of untreated vs. treated contaminants, comparison with cleanup goals, methods of analysis, and treatment residues. More detailed information on documenting technology performance is provided in Chapter 5 of this guide (Paragraph 5-1).

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[1] Note that changes to the remedy selected in the ROD that occurred during the RD/RA process must be described in an Explanation of Significant Differences (ESD) or a ROD Amendment pursuant to NCP §§300.435(c)(2) and 300.825(a) that is provided separately from the RA report.

Exhibit 4-6
Example Performance Standards and Construction Quality Control (Section 5)

Performance Standards

The quantity of soil treated by landfarming was 8,100 yd^3. Initial concentrations of PAHs in untreated, stockpiled soil ranged from 100 to 208 mg/kg. Upon completion of land treatment, the concentration of TCICs in soil ranged from 23 to 92 mg/kg.

All soil and sludge samples collected during operation of the land treatment area were analyzed for PAHs. EPA Method 8270 was used to measure the concentrations of PAHs in all samples. Composite samples were collected quarterly from eight subplots in the land treatment area over an 18-month operating period. Once the cleanup goal had been achieved in a subplot, that subplot was not monitored further until an additional lift of soil was applied to the subplot.

Performance Results Compared with Remediation Objectives

Remediation Objectives	Performance Results
Reduce concentration of TCICs to 100 mg/kg.	Sampling conducted in June 1998 indicated that the concentration of TCICs was less than 100 mg/kg and ranged from 23 to 92 mg/kg in the eight subplots.
Attain desired remediation objectives within two years after startup of the land treatment operation.	Cleanup levels were attained within 18 months after startup of the land treatment operation.
Identify, remove, stabilize, and dispose (off-site) of excavated OU 2 soils with TCIC levels greater than 5,000 mg/kg.	Sampling detected no soils with contamination above this specified level.

Quality Assurance and Quality Control

The QA/QC program used throughout the operation of the land treatment area was outlined in the RD/RA work plan and quality assurance project plan (QAPP) approved by EPA. The program enabled EPA to determine that all analytical results reported were accurate and adequate to ensure satisfactory execution of the remedial action, in a manner consistent with the requirements of the ROD.

The RA contractor conducted sampling and analysis activities on the soils each quarter. EPA took split samples during three sampling events, including the final sampling event on June 28, 1998. EPA periodically conducted oversight of the PRP contractor's field sampling procedures. While deviations from the approved protocols were identified, none was sufficiently significant to cause rejection of the data. Matrix spike, duplicate, and blank samples were analyzed by the laboratory, and the resulting data provided to EPA. On the basis of the split sample data, the confirmatory sampling data were acceptable to EPA. The Florida Department of Environmental Regulation (FDER) also reviewed the data and found the data to be acceptable.

The QA/QC program is also being used for the semiannual sampling of groundwater.

4-7. Final Inspections and Certifications. This section should report the results of the various RA contract inspections, and should identify any noted deficiencies. Adherence to health and safety requirements while implementing the RA should be described briefly. Any substantial problems or deviations should be explained. This section should summarize details of the institutional controls, if implemented, (e.g., the type of institutional control, who will maintain the control, and who will enforce the control). For PRP-lead projects, a description of the pre-certification inspection results should be included. If applicable, the date that the remedy was determined to be O&F should also be included. An example section is provided in Exhibit 4-7.

Exhibit 4-7
Example Final Inspections and Certifications (Section 6)

Inspections

The pre-final inspection of the land treatment area construction was held on-site December 12, 1996, in the presence of EPA, PRP, and FDER representatives. The FDER representative noted the need to fence the lagoon for the protection of the public, and a fence was constructed around the lagoon area.

The final inspection was conducted January 12, 1997. EPA, the PRPs, FDER, the Florida Department of Health and Rehabilitative Services (FDHRS), the Suwanee County Coordinator, and the Mayor of Live Oak were present.

Representatives verified by review of the manifests that the 7,500 cubic yards of solidified OU1 waste had been properly transported and disposed off-site at the CWM landfill in Emelle, Alabama. No punch-list items were identified, and land treatment of the stockpiled contaminated soil was authorized to begin immediately.

Observations, inspections, and testing during operation of the land treatment process found no significant operational problems affecting the performance of the remedial action. A business east of the site reported experiencing nuisance smells after the contaminated soils in the land treatment area were tilled. In response, an effort was made to till when the wind direction was away from the businesses to the east of the site. No further comments about odors were received during the land treatment operation.

Health and Safety

No health and safety problems were encountered during construction or operation. Modified Level D personal protective equipment (PPE) was required for all site personnel who came into direct contact with the contaminated soil. The equipment included coveralls, safety boots, nitrile gloves, and particulate masks.

Certification of Completion

A pre-certification inspection of the completed remedial action was conducted on September 22, 1998, by representatives of the PRPs, EPA and the FDER. On October 17, 1998, the PRPs provided a written report that the remedial action has been fully performed and the performance standards of the consent decree have been attained.

4-8. **Operation & Maintenance Activities.** This section should describe the general activities included as post-construction O&M, such as monitoring, site maintenance, and closure activities. This can include both short-term (RA operating) and long-term (post-RA) O&M. Information regarding any LTRAs and PRP LRs should also be included in this section. Any potential problems or concerns with these activities should be identified here. The results of any optimization efforts during O&M should be noted. If an interim RA report is being completed, the future groundwater or surface water restoration activities should be described. An example O&M activities section is provided in Exhibit 4-8.

Exhibit 4-8
Example Operations & Maintenance Activities (Section 7)

The land treatment area was grass-seeded in September 1998. The vegetative cover will be reseeded in Spring 1999 as necessary.

The semiannual groundwater monitoring program began in January 1997. No TCICs have been detected as of the July 1998, sampling; however, naphthalene has been detected persistently at low levels in groundwater monitoring well No. 7. The levels of naphthalene are below any action level. As specified in the ROD, the PRPs will continue semi-annual monitoring of groundwater through 2002 to confirm that groundwater will not be adversely impacted by the land treatment activities.

4-9. **Summary of Project Costs.**

a. This section should present the total costs incurred for the remedial action. These costs can be designated as capital, O&M, or periodic costs, as described in Chapter 6. Further, these costs can be designated as RA or post-RA costs (e.g., RA capital costs, RA operating costs, post-RA O&M costs).

b. The reporting of project costs is required for government-financed projects and should be provided whenever possible for PRP-lead projects. If the project is PRP-lead, a summary of government oversight costs for the RD and RA should be included.

c. The year(s) in which costs were incurred should be indicated. If actual costs are not available, estimated costs should be provided (e.g., when pending claims may impact final cost).

d. Total project costs at the time of RA completion, actual or estimated, should be compared to the costs estimated in the ROD for the selected remedy, adjusted to the same dollar basis year. Adjustment can be made using an escalation factor, for which the index or rate used should be noted (e.g., Engineering News Record building cost index). If the total project costs lie outside a range of –30 to +50 percent of the ROD estimate, explanation for these differences should be included. An example summary of project costs is provided in Exhibit 4-9.

e. In addition to reporting total costs, a cost breakdown, identifying cost elements, should be provided in an appendix to the RA report. More detailed information on documenting project costs is provide in Chapter 6 of this guide.

Exhibit 4-9
Example Summary of Project Costs (Section 8)

The table below provides a summary of the total project costs and a comparison of the actual costs with the ROD estimate. Appendix B provides additional project cost breakdown.

Cost Summary

Cost Item	ROD Estimate (1996 $$)	ROD Estimate (1998 $$)[1]	Actual Cost (1998 $$)
RA Capital Cost	$266,000	$282,000	$303,026
RA Operating Cost	258,000	273,000	132,497
Total Cost	524,000	555,000	435,523
Projected Future O & M Cost[2]			21,000
Difference between total project cost and total ROD cost estimate[3]	-$119,000 or -22%		

1 ROD Cost was adjusted from 1996 $$ to 1998 $$ using average 1996 and 1998 ENR building cost index factors.
2 Groundwater monitoring was not included in original ROD. Assumed length of monitoring = 5 years
3 Difference between project cost and ROD estimate is largely attributable to 18 months of actual treatment instead of 24 months planned in the ROD.

4-10. Observations and Lessons Learned. This section should discuss site- or OU-specific observations and lessons learned, highlighting successes, problems and their resolutions. The discussion of the problems and their resolutions will be included in the useful technical information that will be extracted by the government and compiled for use in future remedy selections. The information presented should be technical in nature and specific to the site. Observations or lessons learned relating to both cost and performance of the remedial action are important to note. An example section is provided in Exhibit 4-10.

Exhibit 4-10
Example Observations and Lessons Learned (Section 9)

- The project cost 22% less than the adjusted ROD estimate, largely due to reduced labor and materials costs associated with achieving remediation objectives in 18 instead of 24 months. Use of an on-site laboratory also contributed to savings.
- The land treatment application was found to be more effective at remediating soils on the site when the soils were tilled once every two weeks, rather than once every four weeks, as was originally planned.
- Application of fertilizers to the soils at the site proved to be unnecessary because of the naturally high concentrations of inorganic nitrogen and phosphorous in the soil.

Exhibit 4-10, cont.
Example Observations and Lessons Learned (Section 9)

- The relatively mild year-round temperatures at the site provided a beneficial growing environment for the inoculum of PAH-degrading microorganisms. Consequently, relatively high numbers of microorganisms remained in the soil, thus reducing the need for repeated soil inoculations.
- Soils at the site were difficult to till after heavy rains. Natural drying of the soil took an average of two weeks before tractors could be operated on the land treatment area.
- Nuisance odors were reported on days when soils were tilled. Therefore, measures were taken to till on days when the wind direction was away from neighboring properties.

4-11. Operable Unit Contact Information. This section should provide contact information (names, addresses, phone numbers, and contract reference data) for the major design and remediation contractors and subcontractors, oversight contractors, and the respective project managers for the government and the PRPs, as applicable. If available, O&M contact information should be included, such as the prime O&M contractor, subcontractors, and oversight contractors. Contract numbers for the RA and O&M should also be listed, if available. If all available information has already been provided as part of the abstract, this section may be excluded from the RA report. Example information blocks are shown in Exhibit 4-11.

Exhibit 4-11
Example Operable Unit Contact Information (Section 10)

Remedial Action Contractor: *Primary Contact Name and Title:* *Company Name:* *Address:* *Phone Number:*	
RA Oversight Contractor: *Company Name:* *Address:* *Phone Number:*	*Contract Number:* *Work Assignment Number:*
Analytical Laboratory: For the PRPs: *Company Name:* *Address:* *Phone Number:*	

Exhibit 4-11, cont.
Example Operable Unit Contact Information (Section 10)

For the government: *Contract Number:* *Company Name:* *Address:* *Phone Number:*
Project Management: For the PRPs: *Name:* *Company Name:* *Address:* *Phone Number:* For the government: *Name:* *U.S. EPA Region:* *Address:* *Phone Number:*

4-12. References. All references used in preparing the RA report, as well as key documents relating to the RA, should be listed in the references section of the RA report. Examples of documents to reference include the ROD, ROD amendment, remedial design documents, key correspondence/deliverables during the RA, and as-built drawings.

CHAPTER 5
DOCUMENTING TECHNOLOGY PERFORMANCE

5-1. General. This chapter provides additional information on documenting technology performance in the RA report, expanding on concepts presented in the previous chapter (Paragraph 4-6). Technology performance should be documented in Section 5 and Appendix A of the RA report.

5-2. Recommended Performance Reporting.

a. The performance of a technology is often characterized only in terms of the percentage of contaminants removed or the concentration of contaminants remediated. However, that information alone will not adequately assess all aspects of a technology's performance. For example, this one-dimensional measure of performance will not document any of the problems that might have arisen during the technology's application, or how such problems were resolved. The information listed in Exhibit 5-1 should be included in the RA report so that the effectiveness and the appropriateness of the remedy can be quantified and compared with other alternatives when making future remedy selections at other sites with similar characteristics.

b. Exhibit 5-1 provides a guide to ensure that all important information related to the performance of the technology will be documented in the RA report. The level of detail and data available for each performance topic will vary by technology type and the specific application.

Exhibit 5-1
Recommended Performance Reporting

Performance Topic	Type of Information
Types of samples collected	♦ Types of media sampled ♦ Types of constituents analyzed ♦ Use of surrogates (e.g., soil gas as a surrogate for soil borings)
Sample frequency and protocol	♦ Where samples were collected ♦ How samples were collected ♦ When samples were collected ♦ Who collected samples
Quantity of material treated	♦ Quantity of material treated during application ♦ For in situ technologies, area and depth of contaminated material treated
Concentrations of untreated and treated contaminants (range and median values)	♦ Measurement of initial conditions (even if not required to demonstrate compliance with cleanup/remediation criteria) ♦ Measurement of concentrations of contaminants during or after treatment (note whether data exists for both treated and untreated contaminants or whether operating data exists that corresponds with performance data) ♦ Assessment of percent removal achieved (note procedure used to derive percent removal) ♦ Correlation of performance data with other variables

Exhibit 5-1, cont.
Recommended Performance Reporting

Performance Topic	Type of Information
Cleanup goals and/or remediation objectives	♦ Cleanup goals and/or remediation objectives and source(s) ♦ Criteria for ceasing operation
Comparison with cleanup goals/remediation objectives	♦ Assessment of whether the technology achieved the cleanup goals/remediation objectives ♦ Assessment of whether the technology achieved reductions in concentrations of contaminants beyond the established cleanup goals/remediation objectives
Method of analysis	♦ Methods of analysis used (including field screening and/or analyses, portable instruments, mobile laboratory, off-site laboratory, laboratory procedures, analytical methods, explanation of any nonstandard methods) ♦ Exceptions to standard methodologies
Quality assurance and quality control (QA/QC)*	♦ Person responsible for QA/QC ♦ Type of QA/QC measures performed ♦ Level of procedures ♦ Exceptions to QA/QC protocol or data quality objectives
Other residues	♦ Types of residues generated (e.g., off-gases, wastewaters, or sludges) ♦ Measurement of mass or volume, and concentration of contaminants in each treatment residue

* Note that only general QA/QC information is recommended; any exceptions to the QA/QC procedures should be documented.

c. For RA reports involving long-term response actions, such as groundwater pump and treat remedies, interim RA reports should include the most recent performance results, and information about the project's progress and status in order to indicate how well a technology has been performing over time. Final RA reports should update the performance data included in the interim report once the project has been completed.

5-3. Factors that Affect Cost and Performance.

a. The *Guide to Documenting and Managing Cost and Performance Information for Remediation Projects* (EPA 542-B-98-007) lists factors that can affect the cost or performance of a treatment technology and recommends that those factors be documented when reporting technology cost and performance. These include matrix characteristics, such as soil types, soil properties, and organic contaminants that may be present in a matrix being treated; and operating parameters of the treatment system, such as residence time and system throughput. Nonmatrix characteristics such as geology and hydrogeology for in situ applications are also important to document. Technologies for which factors are provided are listed in Exhibit 5-2. Suggested parameters to report for these technologies are provided in Exhibit 5-3.

Exhibit 5-2
Example Remedial Technologies

Ex Situ Soil Remediation	Groundwater Remediation and/or Containment
♦ Composting ♦ Incineration ♦ Land Treatment ♦ Slurry-Phase Bioremediation ♦ Soil Washing ♦ Stabilization ♦ Thermal Desorption	♦ Air Sparging ♦ Bioremediation ♦ Bioslurping ♦ Circulating Wells (UVB) ♦ Cosolvents and Surfactants ♦ Multi-Phase Extraction ♦ Dynamic Underground Stripping ♦ In Situ Oxidation (Fenton's Reagent) ♦ Natural Attenuation (Chlorinated Compounds) ♦ Natural Attenuation (Nonchlorinated Hydrocarbons) ♦ Permeable Reactive Barriers ♦ Phytoremediation ♦ Pump and Treat System ♦ Steam Flushing ♦ Vertical Barrier Walls
In Situ Soil Remediation and/or Containment ♦ Bioventing ♦ Capping ♦ In Situ Heating ♦ Phytoremediation ♦ Soil Flushing ♦ Soil Vapor Extraction ♦ Vitrification	

b. For the RA report, both matrix characteristics and operating parameters of the treatment system should be reported in an appendix as well as site conditions (e.g., geology/hydrogeology), as applicable, that may impact the cost and performance of the treatment technologies used in the remedy. The appendix should report the values or results of each parameter as well as the procedures used to measure the parameter.

Exhibit 5-3
Suggested Parameters to Report that Affect Cost and Performance

Technology / Operating Parameters		Soil Types		Aggregate Soil Matrix Properties						Organic Properties			System Parameters									Biological Activity						Misc.
	Technology	Soil Classification	Clay Content and/or Particle Size Distribution	Hydraulic Conductivity	Moisture Content	Air Permeability	pH	Porosity	Depth or Thickness of Zone of Interest	Total Organic Carbon	Oil and Grease or Total Petroleum Hydrocarbons	Presence of NAPLs	Air Flow Rate	Mixing Rate / Frequency	Operating Pressure / Vacuum	pH	Pumping Rate	Residence Time	System Throughput	Temperature	Components/Additives & Dosage for Wash/Flush	Biomass Concentration	Microbial Activity	Oxygen Uptake Rate	Carbon Dioxide Evolution	Biodegradation Rate for Organics	Nutrients and Other Soil Amendments	Miscellaneous
In Situ Soil Remediation and/or Containment	Bioventing	●	●		●	●	●	●	●	●		●	●		●					●				●	●	●	●	
	Capping	●	●	●	●											●				●								●[1]
	In Situ Heating	●	●		●	●		●	●	●		●			●	●				●								●[2]
	Phytoremediation	●	●	●	●		●		●	●						●				●							●	●[3]
	Soil Flushing	●	●	●			●		●	●	●	●				●	●	●			●							
	Soil Vapor Extraction	●	●		●	●		●	●	●		●	●		●													
	Vitrification	●	●		●	●			●											●								●[4]
Ex Situ Soil Remediation	Composting	●	●		●		●						●	●		●		●	●	●				●		●	●	●[5]
	Incineration	●	●		●					●			●					●	●	●								●[6]
	Land Treatment	●	●		●		●			●				●		●		●		●						●	●	●[7]
	Slurry-Phase Bioremediation	●	●		●		●						●	●		●		●	●	●		●				●	●	●[8]
	Soil Washing	●	●							●						●		●	●	●	●							●[9]
	Stabilization	●	●		●		●			●	●								●	●	●							●[10]
	Thermal Desorption	●	●		●						●							●	●	●								●[11]

Nonmatrix Characteristics that Affect Cost or Performances

Contaminants: Type and concentration of contaminants.

Cleanup goals/remediation objectives and requirements: Maximum contaminant levels, schedules, sampling and analysis.

Environmental Setting (for In Situ Technologies): Geology, stratigraphy, and hydrogeology (primarily).

Quantiy of material treated. Cubic yards or 1,000 gallons of water.

Notes

[1] Future use; precipitation; design infiltration rate; permeability of clay liner, geomembrane, or other polymer layers

[2] Electrical conductivity (for electrical heating); electrical or radio frequency (RF) power input

[3] Plants per unit area and plant type

[4] Lower explosive limit; glass-forming metals; electrical conductivity; power consumption per unit volume; presence of inclusions

[5] Moisture content; soil loading rate

[6] BTU value; halogen content; metal content

[7] Field capacity; moisture content

[8] Density of slurry; volume fraction of water

[9] Cation exchange capacity of soils

[10] Curing time; compressive strength; volume increase; permeability

[11] Bulk density

Exhibit 5-3, cont.
Suggested Parameters to Report that Affect Cost and Performance

Technology / Operating Parameters		Soil Types		Aggregate Soil Matrix Properties						Organic Properties			System Parameters									Biological Activity						Misc.
		Soil Classification	Clay Content and/or Particle Size Distribution	Hydraulic Conductivity	Moisture Content	Air Permeability	pH	Porosity	Depth or Thickness of Zone of Interest	Total Organic Carbon	Oil and Grease or Total Petroleum Hydrocarbons	Presence of NAPLs	Air Flow Rate	Mixing Rate / Frequency	Operating Pressure / Vacuum	pH	Pumping Rate	Residence Time	System Throughput	Temperature	Components/Additives & Dosage for Wash/Flush	Biomass Concentration	Microbial Activity	Oxygen Uptake Rate	Carbon Dioxide Evolution	Biodegradation Rate for Organics	Nutrients and Other Soil Amendments	Miscellaneous
Groundwater Remediation and/or Containment	Air Sparging	●	●	●		●		●	●			●	●		●													
	Bioremediation	●	●	●			●		●	●	●	●				●				●	●		●	●	●	●	●	
	Bioslurping	●	●	●	●	●	●	●	●	●	●	●	●		●		●							●	●	●	●	
	Circulating Wells (UVB)	●	●	●		●			●			●	●		●		●										●	
	Cosolvents/Surfactants	●	●	●		●			●	●	●	●				●	●	●			●							●[12]
	Dual-Phase Extraction	●	●	●		●		●	●		●	●	●		●		●											
	Dynamic Underground Stripping	●	●	●		●		●	●			●	●		●		●			●								
	In Situ Oxidation (Fenton's Reagent)	●	●	●			●		●							●	●				●		●					●[13]
	Natural Attenuation (Chlorinated)	●	●	●			●		●	●		●				●				●			●		●	●	●	●[14]
	Natural Attenuation (Nonchlorinated)	●	●	●			●		●	●	●	●				●				●			●	●	●	●	●	●[15]
	Permeable Reactive Barriers	●	●	●			●	●	●	●		●				●												●[16]
	Phytoremediation	●	●	●			●		●	●						●				●							●	●[17]
	Pump and Treat System	●	●	●					●			●				●	●											●[18]
	Steam Flushing	●	●	●		●			●		●	●					●			●								
	Vertical Barrier Walls	●	●	●				●	●																			●[19]

Nonmatrix Characteristics that Affect Cost or Performances

Contaminants: Type and concentration of contaminants.

Cleanup goals/remediation objectives and requirements: Maximum contaminant levels, schedules, sampling and analysis.

Environmental Setting (for In Situ Technologies): Geology, stratigraphy, and hydrogeology (primarily).

Quantiy of material treated. Cubic yards or 1,000 gallons of water.

Notes

12 Efficiency of recovery and recycling

13 Injection rates; costs of chemicals

14 Redox conditions; electron acceptors (oxygen, nitrate, iron, sulfate, methane); electron donors (e.g., carbon, presence of toluene); presence of breakdown products; levels of ethene, ethane, or methane

15 Dissolved oxygen levels; electron acceptors (oxygen, nitrate, iron, sulfate, methane)

16 Flow rate through gate (for funnel-and-gate system); type of reactant (e.g., iron granules)

17 Plants per unit area and plant type

18 For the treatment component of the pump and treat system, the operating parameters will vary by the specific type of treatment used (e.g., carbon adsorption, air stripper); for additional information, please refer to *Technical Requirements to Report HTRW Environmental Restoration Cost and Performance*, USACE 1996

19 Permeability of wall material and depth of key

c. Exhibits 5-4 and 5-5 provide examples of how matrix characteristics and operating parameters may be reported in Appendix A of the RA report for a remedial action that uses a land treatment system to remediate contaminated soil.

Exhibit 5-4
Example Matrix Characteristics

Parameter	Value/Result	Measurement Procedure
Soil Types		
Soil classification	Mixture of lagoon contents; lagoon had a clay bottom and sandy contents, which ranged from silty clay to fine sand	Because the medium treated was a mixture of lagoon contents, it did not lend itself to a formal classification analysis.
Aggregate Soil Properties		
pH	6.9	The value listed represents an average measured during one of the sampling events; EPA Method SW-846/9045 was used to measure the pH of the soil.
Total organic carbon	16,000 mg/kg	The value listed represents an average measured during one of the sampling events; EPA Method SW-846/9060 was used to measure the total organic carbon in the soil.
Quantity of soil treated	8,100 yd^3 (total for 3 lifts)	NA
NA - not applicable. Measurement procedures are reported only for those parameters where different procedures are available.		

Exhibit 5-5
Example Operating Parameters

Parameter	Value/Result	Measurement Procedure
System Parameters		
Soil mixing rate / frequency	Soil placed in the subplots was tilled every two weeks.	Mixing rate or frequency is the rate of tilling for land treatment.
Soil moisture content (%)	12.4 - 22.8 (Lift 1) 12.9 - 21.1 (Lift 2) 8.5 - 14.7 (Lift 3)	Soil moisture was measured using the gravimetric ASTM standard D 2216-90, *Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock*.
pH	6.6 - 7.2 (Lift 1) 6.8 - 7.5 (Lift 2) 6.4 - 7.0 (Lift 3)	Values shown represent the ranges of pH for each lift. EPA Method SW-846/9045 was used to measure the pH content.
Residence time (months)	9 - 15 (Lift 1) 6 - 10 (Lift 2) 4 (Lift 3)	Ranges are given for each lift because of the variations by subplot.
Soil temperature (°F)	13 - 99 (Lift 1) 13 - 102 (Lift 2) 29 - 102 (Lift 3)	NA
Biological Activity		
Carbon/Total Kjeldahl Nitrogen	8.8 - 15.4 (Lift 1) 8.8 - 78 (Lift 2) 6 - 67 (Lift 3)	Values represent the ratio of Carbon to Total Kjeldahl Nitrogen in the soil at the time of measurement for each lift. Ranges are shown for the eight treatment subplots. EPA Methods 415.1 (Modified) and 351.1 (Modified) were used.
Hydrocarbon degradation (mg/kg/month)	13 - 58 (Lift 1) No values were determined for Lifts 2 and 3.	Calculation of hydrocarbon degradation was based on the difference between the initial and final TCIC concentrations in the first lift and dividing that value by the amount of time required for treatment of soil in that cell in the first lift. The values shown represent the range measured for the eight treatment subplots.
PAH degraders (cfu/gm)	1.0x10 5 - 5.0x10 7 (Lift 1) 7.0x10 2 - 4.5x10 6 (Lift 2) No values were determined for Lift 3.	"Replica Plating Method for Estimating Phenanthrene-Utilizing and Phenanthrene-Cometabolizing Micro-organisms," Shiaris, M., Cooney, J., *Applied and Environmental Microbiology*, February 1983, Vol. 45, No. 2, pp. 706-710.
Total heterotrophs (cfu/gm)	7x10 5 - 9.9x10 7 (Lift 1) 6.3x10 5 - 6.6x10 7 (Lift 2) 7.0x10 4 - 1.1x10 7 (Lift 3)	"Agar-Plate Method for Total Microbial Count," F. Clark, *Methods of Soil Analysis*, Vol. 2, pp. 1460-1465.

NA - not applicable. Measurement procedures are reported only for those parameters where different procedures are available.

CHAPTER 6
DOCUMENTING PROJECT COSTS

6-1. General.

a. This chapter provides more detailed information on documenting project costs in the RA report, expanding on concepts presented in Chapter 4 (Paragraph 4-9). For environmental restoration projects, project costs should be reported using primarily the RA (for RA capital and operating costs) and O&M (for post-RA costs) work breakdown structures, which are intended to coincide with the RA and O&M phases of the remedial response process. The use of the RA WBS will help provide RA cost data for input into HCAS. Cost reporting templates for HCAS data entry are provided in Appendix D of this guide. The data from these templates will be input by the USACE HTRW CX into the HCAS software upon receiving the RA report. Cost data should be documented in Appendix B of the RA report.

> **Actual vs. Estimated Costs**
>
> Often, especially at sites involving groundwater remediation, the actual costs associated with the RA will not be available at the time the RA report is being written. In addition, costs may not be available at PRP sites, or because of claims and change orders, which may not be settled until many years after RA completion. In these cases, the best available estimated costs should be used.

b. Each project typically uses a project-specific WBS to roll up costs. For the purposes of upward reporting of costs in a standardized manner in the RA report, these costs must be mapped from the project-specific WBS to the standard HTRW RA WBS. This will permit a standardized roll up of costs for nationwide historical cost input to the HCAS database.

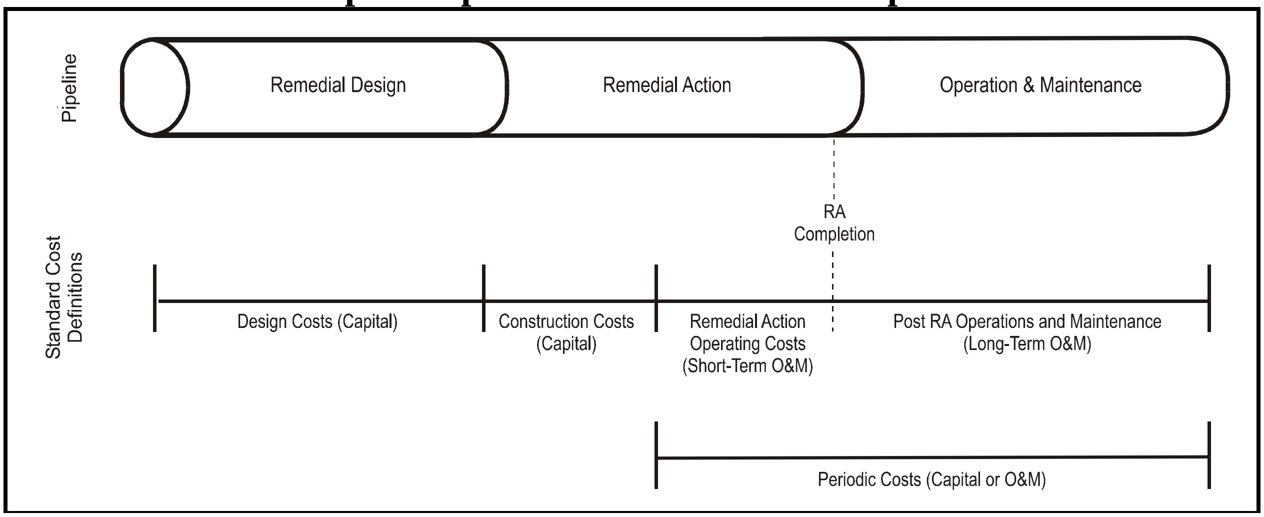
6-2. Definitions. The types of costs to document in the RA report include capital, O&M (RA operating and post-RA O&M), and periodic costs. These are defined below. Figure 6-1 illustrates the relationship of these costs to the RA and O&M phases.

a. Capital costs are those expenditures that are required to construct the RA. They are exclusive of the costs required to operate or maintain the action throughout its lifetime. Capital costs consist primarily of expenditures initially incurred to build or install the remedial action (e.g., construction of a groundwater treatment system and related site work). Capital costs include all labor, equipment, and material costs, including contractor markups such as overhead and profit, associated with construction activities. The RA WBS should be primarily used to report capital costs. Capital costs can also include expenditures for professional/technical services that are necessary to support construction of the RA.

b. O&M costs are those post-construction costs necessary to ensure or verify the continued effectiveness of a remedial action. O&M costs documented in the RA report can include RA operating costs and post-RA O&M costs. The RA WBS should be primarily used to report RA operating costs and the O&M WBS should be primarily used to estimate post-RA O&M costs. O&M costs include all labor, equipment, and material costs, including contractor markups such as overhead and profit, associated with O&M activities. O&M costs can also include expenditures for professional/technical services necessary to support O&M activities.

c. Periodic costs are those capital or O&M costs that occur only once every few years (e.g., five-year reviews, equipment replacement) or expenditures that occur only once during the entire O&M period or remedial timeframe (e.g., site close out). Periodic costs can be incurred during the RA operating period, but are more likely to be incurred during the post-RA O&M period. Either the RA or O&M WBS can be used to report periodic costs.

Exhibit 6-1
Relationship of Capital and O&M Costs to Pipeline Phases



6-3. <u>Cost Element Structure</u>. All applicable capital, O&M, and periodic costs should be documented in the RA report. To help identify the cost element structure to report costs; capital, O&M, and periodic cost elements are described in Exhibits 6-2, 6-3, and 6-4, respectively. Exhibits 6-2 and 6-3 includes second-level elements from the HTRW RA and O&M work breakdown structures, respectively, for construction and O&M activities. Professional/technical services and institutional controls have been added to the descriptions in Exhibits 6-2 and 6-3; however, these costs are not reported into HCAS. More information on the RA and O&M work breakdown structures is provided below.

a. The RA WBS, Account 33XXX, includes construction (RA capital) and operation during the remedial action (RA operating). Account 33XXX excludes all project management at all phases and excludes pre construction investigations and remedial design. Account 33XXX excludes post construction O&M, which is in Account 34XXX.

b. The O&M WBS, Account 34XXX, includes post construction O&M (post RA O&M), which is long term, indefinite term, or caretaker status following remedial action. Account 34XXX includes such items as operation labor and equipment, maintenance and repair, fuel, utilities, bulk chemicals, raw materials, plant ownership/rental, plant upgrades and replacements, transport waste materials to the plant, preparation and handling of waste materials at the plant, training, regulatory approvals, etc.

6-4. <u>Capital Cost Elements</u>. The majority of the capital cost elements listed in Exhibit 6-2 are construction activities (e.g., sitework) that are incurred as part of the physical construction of the RA. Project management, remedial design, and construction management are professional/technical services to support construction of the remedial action. Institutional controls, which are legal or administrative measures used to limit or restrict site access, can be a major component of the RA (if required) and therefore warrant separate consideration. Contingency is not included as a separate cost element since the costs reported in the RA report are known, or actual, RA costs.

Exhibit 6-2
RA Capital and Operating Cost Elements

Cost Element	Description
331XX.01 Mobilization and Preparatory Work	Includes all preparatory work required during remedial action or construction. This includes submittals; construction plans; mobilization of personnel, facilities and equipment; construction of temporary facilities; temporary utilities; temporary relocations and setup of decontamination facilities and construction plant.
331XX.02 Monitoring, Sampling, Testing, and Analysis	Provides for all work during remedial action associated with air, water, sludge, solids and soil sampling, monitoring, testing, and analysis. Includes sample taking, shipping samples and sample analysis by on-site and off-site laboratory facilities.
331XX.03 Sitework	Sitework during remedial action consists of site preparation, site improvements, and site utilities. Site preparation includes demolition, clearing, and earthwork. Site improvements include roads, parking, curbs, gutters, walks and other hardscaping. Site utilities include water, sewer, gas, other utility distribution. Also includes new fuel storage tanks. All work involving contaminated or hazardous material is excluded from this system. Storm drainage involving contaminated surface water is included under "Surface Water Collection and Control" (331XX.05). Note that topsoil, seeding, landscaping and reestablishment of existing structures altered during remediation activities are included in "Site Restoration" (331XX.20).
331XX.04 Ordnance and Explosive-Chemical Warfare Material Removal and Destruction	Includes the locating, removing, and destruction of all ordnance, conventional or chemical, fused or unfused, related scrap, propellants, and delivery vehicles during remedial action. Providing for public involvement, providing subsurface data for the delineating the extent of the contamination. Also includes the construction of temporary explosive storage bunkers and surveys.
331XX.05 Surface Water Collection and Control	Provides for the collection and control of contaminated surface water through the construction of storm drainage piping and structures, erosion control measures, and civil engineering structures such as berms, dikes and levees. Includes the collection of surface water through the construction of lagoons, basins, tanks, dikes, and pump systems. Includes transport to treatment plant.
331XX.06 Groundwater Collection and Control	Provides for the remedial action collection and control of contaminated groundwater through the construction of piping, wells, trenches, slurry walls, sheet piling and other physical barriers. Includes the collection of groundwater through the construction of lagoons, basins, tanks, dikes, and pump systems. Includes transport to treatment plant.
331XX.07 Air Pollution/Gas Collection and Control	Includes the remedial action construction for the collection and control of gas, vapor and dust.

Exhibit 6-2, cont.
RA Capital and Operating Cost Elements

Cost Element	Description
331XX.08 Solids Collection and Containment	Provides for exhuming and handling of solid hazardous, toxic and radioactive waste (HTRW) during remedial action through excavation, sorting, stockpiling, and filling containers. Provides for containment of solid waste through the construction of multilayered caps as well as dynamic compaction of burial grounds, cribs, or other waste disposal units. Includes transport to treatment plant.
331XX.09 Liquids/Sediment/Sludge Collection and Containment	Includes collection during remedial action of HTRW-contaminated liquids and sludges through dredging and vacuuming, and the furnishing and filling of portable containers. Includes the containment of liquids and sludges through the construction of lagoons, basins, tanks, dikes, and drain system. Includes transport to treatment plant.
331XX.10 Drums/Tanks/Structures/Miscellaneous Demolition and Removal	Includes the demolition and removal during remedial action of HTRW contaminated drums, tanks, contaminated paint removal, and other structures by excavation and downsizing. Does not include filling portable hazardous waste containers or transport of wastes to treatment or disposal facilities. See "Solids Collection and Containment" (331XX.08), "Disposal (Other than Commercial)" (331XX.18), and "Disposal (Commercial)" (331XX.19)
331XX.11 Biological Treatment	Includes operation (separate items for each subsystem technology) of the plant facility during the remedial action phase, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (331XX.11.(01.-14.)). Includes a separate item for the construction of a permanent plant facility, including permanent treatment equipment which is purchased for one project only (331XX.11.50.). Biological treatment is the microbial transformation of organic compounds. Biological treatment processes can alter inorganic compounds such as ammonia and nitrate, and can change the oxidation state of certain metal compounds. Includes in-situ biological treatment such as land farming as well as activated sludge, composting, trickling filters, anaerobic, and aerobic digestion. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (331XX.05.11, 331XX.06.08, 331XX.08.03 or 331XX.09.04).
331XX.12 Chemical Treatment	Includes operation (separate items for each subsystem technology) of the plant facility during the remedial action phase, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (331XX.12.(01.-14.)). Includes a separate item for the construction of a permanent plant facility, including permanent treatment equipment which is purchased for one project only (331XX.12.50.). Chemical treatment is the process in which hazardous wastes are chemically changed to remove toxic contaminants from the environment. Type of treatment included in this system are oxidation/reduction, solvent extraction, chlorination, ozonation, ion exchange, neutralization, hydrolysis, photolysis, dechlorination, and electrolysis reactions. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (331XX.05.11, 331XX.06.08, 331XX.08.03 or 331XX.09.04).

Exhibit 6-2, cont.
RA Capital and Operating Cost Elements

Cost Element	Description
331XX.13 Physical Treatment	Includes operation (separate items for each subsystem technology) of the plant facility during the remedial action phase, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (331XX.13.(01.-32.)). Includes a separate item for the construction of a permanent plant facility, including permanent treatment equipment which is purchased for one project only (331XX.13.50.). These treatment processes are the physical separation of contaminants from solid, liquid or gaseous waste streams. The treatments are applicable to a broad range of contaminant concentrations. Physical treatments generally do not result in total destruction or separation of the contaminants in the waste stream, consequently post-treatment is often required. Type of physical treatment included in this system are filtration, sedimentation, flocculation, precipitation, equalization, evaporation, stripping, soil washing, and carbon adsorption. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (331XX.05.11, 331XX.06.08, 331XX.08.03 or 331XX.09.04).
331XX.14 Thermal Treatment	Includes operation (separate items for each subsystem technology) of the plant facility during the remedial action phase, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (331XX.14.(01.-07.)). Includes a separate item for the construction of a permanent plant facility, including permanent treatment equipment which is purchased for one project only (331XX.14.50.). Thermal treatment is the destruction of wastes through exposure to high temperature in combustion chambers and energy recovery devices. Several processes capable of incinerating a wide range of liquid and solid wastes include fluidized bed, rotary kiln, multiple hearth, infrared, circulating bed, liquid injection, pyrolysis, plasma torch, wet air oxidation, supercritical water oxidation, molten salt destruction, and solar detoxification. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (331XX.05.11, 331XX.06.08, 331XX.08.03 or 331XX.09.04).
331XX.15 Stabilization/Fixation/ Solidification	Includes operation (separate items for each subsystem technology) of the plant facility during the remedial action phase, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (331XX.15.(01.-07.)). Includes a separate item for the construction of a permanent plant facility, including permanent treatment equipment which is purchased for one project only (331XX.15.50.). Stabilization/fixation/encapsulation processes attempt to improve the handling and physical characteristics of the wastes, decrease the surface area, limit the solubility of any pollutants and detoxify contained pollutants. For transportation see "Transport to Treatment Plant" (331XX.05.11, 331XX.06.08, 331XX.08.03 or 331XX.09.04).
331XX.16 Reserved	Reserved for future use.

Exhibit 6-2, cont.
RA Capital and Operating Cost Elements

Cost Element	Description
331XX.17 Decontamination and Decommissioning (D&D)	Decontamination and decommissioning during remedial action are all activities associated with shutdown and final cleanup of a nuclear or other facility. Includes facility shutdown and dismantling activities, preparation of decommissioning plans, procurement of equipment and materials, research and development, spent fuel handling, and hot cell cleanup.
331XX.18 Disposal (Other than Commercial)	Includes operation (separate items for each subsystem disposal method) of the plant facility during the remedial action phase, based on the volume of waste material disposed, including portable treatment equipment which is charged on a time basis and can be used on more than one project (331XX.18.(01.-10.)). Includes a separate item for the construction of a permanent disposal facility, including permanent disposal equipment, which is purchased for one disposal facility only (331XX.18.15.). Disposal (Other than Commercial) provides for the final placement of HTRW or ordnance at facilities owned or controlled by the Government. An example would be the disposal of wastes through burial at a DOE nuclear facility or ordnance disposal at DOD facilities. Includes handling, disposal fees, and transportation to the final Destruction/Disposal/Storage facility. Excluded is the transportation to a facility for treatment prior to final disposal. For transportation prior to final disposal see "Transport to Treatment Plant" (331XX.05.11, 331XX.06.08, 331XX.08.03 or 331XX.09.04). Disposal may be accomplished through the use of secure landfills, burial grounds, trench, pits, above ground vault, underground vault, underground mine/shaft, tanks, pads (tumulus / retrievable storage, other), storage buildings or protective cover structures, cribs, deep well injection, incinerator, or other.
331XX.19 Disposal (Commercial)	Commercial disposal during remedial action provides for the final placement of HTRW at third party commercial facilities that charge a fee to accept waste depending on a variety of waste acceptance criteria. Fees are assessed based on different waste categories, methods of handling, and characterization. Disposal may be accomplished through the use of secure landfills, surface impoundments, deep well injection, or incineration. Includes transportation to the final Destruction/Disposal/Storage facility. Excludes transportation to a facility for treatment prior to disposal. For transportation see "Transport to Treatment Plant" (331XX.05.11, 331XX.06.08, 331XX.08.03 or 331XX.09.04).
331XX.20 Site Restoration	Site restoration during remedial action includes topsoil, seeding, landscaping, restoration of roads and parking, and other hardscaping disturbed during site remediation. Note that all vegetation and planting is to be included as well as the installation of any site improvement damaged or altered during construction. All vegetation and planting for the purpose of erosion control during construction activities should be placed under "Erosion Control" (331XX.05.13). Treated soil used as backfill will be placed under "Disposal (Other than Commercial)" (331XX.18). All new site improvements, those not disturbed during construction, are to be included under "Sitework" (331XX.03).

Exhibit 6-2, cont.
RA Capital and Operating Cost Elements

Cost Element	Description
331XX.21 Demobilization	Provides for all work associated with remedial action plant takedown and removal of temporary facilities, utilities, equipment, material, and personnel.
331XX.9x Other	Includes all Hazardous, Toxic, Radioactive Waste Remedial Action work not described by the above-listed systems.
Project Management	Professional/technical services to support construction or installation of remedial action not specific to remedial design or construction management.
Remedial Design	Professional/technical services to design the remedial action, including pre-design activities to collect the necessary data.
Construction Management	Professional/technical services to manage construction or installation of remedial action, excluding any similar services provided as part of construction activities.
Institutional Controls	Non-engineering (i.e., administrative or legal) measures to reduce or minimize potential for exposure to site contamination or hazards (i.e., limit site access or restrict site access).

6-5. O&M Cost Elements.

a. Many of the O&M cost elements listed in Exhibit 6-3 are incurred as part of physical operation and maintenance activities. Project management and technical support are professional/technical services to support O&M activities. Institutional controls may require annual update or maintenance to ensure potential for exposure to site contamination or hazards is reduced or minimized. Contingency, which covers unknowns or unanticipated conditions associated with future O&M activities, should be added to the total of projected O&M costs (i.e., post-RA O&M), which are estimated only at the time of the RA report.

b. O&M costs can vary and may be estimated for different time periods, depending on the operating conditions and requirements. For example, the first five years of a groundwater monitoring program may require semiannual sampling, while the next twenty years may only require annual sampling. Likewise, an installed cap or cover may require more frequent inspections during the first year of O&M than during subsequent years.

Exhibit 6-3
Post-RA O&M Cost Elements

Cost Element	Description
342XX.02 Monitoring, Sampling, Testing, and Analysis	Provides for all work during post construction O&M associated with air, water, sludge, solids and soil sampling, monitoring, testing, and analysis. Includes sample taking, shipping samples and sample analysis by on-site and off-site laboratory facilities.
342XX.03 Sitework	Post construction O&M. Sitework includes site improvements, and site utilities. Site improvements include roads, parking, curbs, gutters, walks and other hardscaping. Site utilities include water, sewer, gas, other utility distribution. Also includes fuel storage tanks. All work involving contaminated or hazardous material is excluded from this system. Storm drainage involving contaminated surface water is included under "Surface Water Collection and Control" (342XX.05).
342XX.05 Surface Water Collection and Control	Provides for post construction O&M of the system for the collection and control of contaminated surface water through storm drainage piping and structures, erosion control measures, and civil engineering structures such as berms, dikes and levees. Includes transport to treatment plant.
342XX.06 Groundwater Collection and Control	Provides for post construction O&M of the system for the collection and control of contaminated groundwater through piping, wells, trenches, slurry walls, sheet piling and other physical barriers. Includes transport to treatment plant.
342XX.07 Air Pollution/Gas Collection and Control	Includes the post construction O&M of the system for collection and control of gas, vapor, and dust.
342XX.08 Solids Collection and Containment	Provides for post construction O&M of the system for exhuming and handling of solid hazardous, toxic and radioactive waste (HTRW) through excavation, sorting, stockpiling, and filling containers. Provides for post construction O&M of multilayered caps. Includes transport to treatment plant.
342XX.09 Liquids/Sediments/Sludge Collection and Containment	Includes post construction O&M of the system for collection of HTRW-contaminated liquids and sludges through dredging and vacuuming, and the furnishing and filling of portable containers. Includes the post construction O&M of the system for containment of liquids and sludges through lagoons, basins, tanks, and dikes. Includes transport to treatment plant.

Exhibit 6-3, cont.
Post-RA O&M Cost Elements

Cost Element	Description
342XX.11 **Biological Treatment**	Includes post construction O&M (separate for each subsystem technology) of the plant facility, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (342XX.11.(01.-14.)). Includes a separate item for the yearly post construction O&M of a permanent plant facility (342XX.11.50.). Biological treatment is the microbial transformation of organic compounds. Biological treatment processes can alter inorganic compounds such as ammonia and nitrate, and can change the oxidation state of certain metal compounds. Includes in-situ biological treatment such as land farming as well as activated sludge, composting, trickling filters, anaerobic, and aerobic digestion. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (342XX.05.11, 342XX.06.08, 342XX.08.03 or 342XX.09.04).
342XX.12 **Chemical Treatment**	Includes post construction O&M (separate for each subsystem technology) of the plant facility, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (342XX.12.(01.-14.)). Includes a separate item for the yearly post construction O&M of a permanent plant facility (342XX.12.50.). Chemical treatment is the process in which hazardous wastes are chemically changed to remove toxic contaminants from the environment. Type of treatment included in this system are oxidation/reduction, solvent extraction, chlorination, ozonation, ion exchange, neutralization, hydrolysis, photolysis, dechlorination, and electrolysis reactions. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (342XX.05.11, 342XX.06.08, 342XX.08.03 or 342XX.09.04).
342XX.13 **Physical Treatment**	Includes post construction O&M (separate for each subsystem technology) of the plant facility, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (342XX.13.(01.-32.)). Includes a separate item for the yearly post construction O&M of a permanent plant facility (342XX.13.50.). These treatment processes are the physical separation of contaminants from solid, liquid or gaseous waste streams. The treatments are applicable to a broad range of contaminant concentrations. Physical treatments generally do not result in total destruction or separation of the contaminants in the waste stream, consequently post-treatment is often required. Type of physical treatment included in this system are filtration, sedimentation, flocculation, precipitation, equalization, evaporation, stripping, soil washing, and carbon adsorption. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (342XX.05.11, 342XX.06.08, 342XX.08.03 or 342XX.09.04).

Exhibit 6-3, cont.
Post-RA O&M Cost Elements

Cost Element	Description
342XX.14 **Thermal Treatment**	Includes post construction O&M (separate for each subsystem technology) of the plant facility, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (342XX.14.(01.-07.)). Includes a separate item for the yearly post construction O&M of a permanent plant facility (342XX.14.50.). Thermal treatment is the destruction of wastes through exposure to high temperature in combustion chambers and energy recovery devices. Several processes capable of incinerating a wide range of liquid and solid wastes include fluidized bed, rotary kiln, multiple hearth, infrared, circulating bed, liquid injection, pyrolysis, plasma torch, wet air oxidation, supercritical water oxidation, molten salt destruction, and solar detoxification. Includes process equipment and chemicals required for treatment. For transportation see "Transport to Treatment Plant" (342XX.05.11, 342XX.06.08, 342XX.08.03 or 342XX.09.04).
342XX.15 **Stabilization/Fixation/** **Capsulation**	Includes post construction O&M (separate for each subsystem technology) of the plant facility, based on the volume of waste material treated, including portable treatment equipment which is charged on a time basis and can be used on more than one project (342XX.15.(01.-07.)). Includes a separate item for the yearly post construction O&M of a permanent plant facility (342XX.15.50.). Stabilization/fixation/encapsulation processes attempt to improve the handling and physical characteristics of the wastes, decrease the surface area, limit the solubility of any pollutants and detoxify contained pollutants. For transportation see "Transport to Treatment Plant" (342XX.05.11, 342XX.06.08, 342XX.08.03 or 342XX.09.04).
342XX.18 **Disposal (Other than** **Commercial)**	Includes post construction O&M (separate for each subsystem disposal method) of the plant facility, based on the volume of waste material disposed, including portable treatment equipment which is charged on a time basis and can be used on more than one project (331XX.18.(01.-10.)). Includes a separate item for the yearly post construction O&M of a permanent disposal facility (342XX.18.15.). Disposal (Other than Commercial) provides for the final placement of HTRW or ordnance at facilities owned or controlled by the Government. An example would be the disposal of wastes through burial at a DOE nuclear facility or ordnance disposal at DOD facilities. Includes handling, disposal fees, and transportation to the final Destruction/Disposal/ Storage facility. Excluded is the transportation to a facility for treatment prior to final disposal. For transportation prior to final disposal see "Transport to Treatment Plant" (342XX.05.11, 342XX.06.08, 342XX.08.03 or 342XX.09.04). Disposal may be accomplished through the use of secure landfills, burial grounds, trench, pits, above ground vault, underground vault, underground mine/shaft, tanks, pads (tumulus / retrievable storage, other), storage buildings or protective cover structures, cribs, deep well injection, incinerator, or other.
342XX.9X **Other**	Includes all Hazardous, Toxic, Radioactive Waste post construction O&M work not described by the above listed systems.
Contingency	Costs to cover unknowns, unforeseen circumstances, or unanticipated conditions associated with projected post-RA O&M.

Exhibit 6-3, cont.
Post-RA O&M Cost Elements

Cost Element	Description
Project Management	Professional/technical services to manage O&M activities not specific to technical support listed below.
Technical Support	Professional/technical services to monitor, evaluate, and report progress of operation and maintenance.
Institutional Controls	Update or maintenance of non-engineering measures to reduce or minimize potential for exposure to site contamination or hazards.

6-6. <u>Periodic Cost Elements</u>. The periodic cost elements listed in Exhibit 6-4 include both construction or O&M-type activities and professional/technical services. Distinctions should be made between periodic costs that occur during the RA operating and post-RA O&M periods. Contingency should be added to projected periodic costs that may occur during the post-RA O&M period. Periodic costs should be rolled up into the appropriate items of the RA WBS and/or the O&M WBS.

Exhibit 6-4
RA or Post-RA O&M Periodic Cost Elements

Cost Element	Description
Remedy Failure or Replacement	Construction activity to replace an installed remedy or key components of the remedy.
Demobilization of On-Site Extraction, Containment, or Treatment Systems*	Construction activity to dismantle or take down extraction , containment, or treatment facilities upon completion of remedial action. * Specify extraction, containment, or treatment system. Examples include groundwater extraction system, soil vapor extraction system, groundwater treatment facility, etc. More than one system may be associated with an individual alternative.
Contingency (post-RA only)	Costs to cover unknowns, unforeseen circumstances, or unanticipated conditions associated with projected periodic construction/operation activities.
Five-Year Reviews	Professional/technical services to prepare five-year review reports (if hazardous substances, pollutants, or contaminants remain on-site above levels that allow for unrestricted use and unlimited exposure).
Groundwater Performance and Optimization Study	Professional/technical services to analyze and optimize on-going groundwater pump and treat systems.
Remedial Action Report	Professional/technical services to prepare remedial action report upon completion of RA.
Institutional Controls	Periodic update or maintenance of non-engineering measures to reduce or minimize potential for exposure to site contamination or hazards.

6-7. Project Cost Appendix. To support the summary of total project costs in the RA report (Paragraph 4-9 of this guide), cost information should be provided in an appendix to the RA report. This should include a cost breakdown and, if treatment was part of the remedy, calculation of technology-specific unit cost(s).

a. Cost Breakdown

(1) The cost breakdown should be in the form of one- to two-page table(s) that presents all RA capital and operating costs, post-RA O&M costs, and RA or post-RA O&M periodic costs, actual or projected. The table(s) should follow an activity-based format that identifies all cost elements and sub-elements using the RA WBS or O&M WBS, as applicable for each of the types of costs presented (e.g., RA capital costs, RA operating costs, post-RA O&M costs).

(2) Exhibit 6-5 provides an example of how a cost breakdown may be reported in Appendix B of the RA report for a remedial action that uses land treatment system to remediate contaminated soil. In this example, no periodic costs apply.

b. Technology-Specific Unit Cost

(1) The *Guide to Documenting and Managing Cost and Performance Information for Remediation Projects* (EPA 542-B-98-007) presents a recommended format for reporting technology-specific costs. One of the purposes of this format is to enable the calculation of a unit cost using only those items directly related to the performance of a technology. This unit cost could then be used for comparison with unit costs of other technologies. The unit cost calculation excludes all project costs associated with remediation that are not directly attributable to a specific technology. In addition, the technology-specific unit cost calculation should exclude all costs for project management, remedial design, construction management, and technical support that are typically added at the bottom of an estimate or cost breakdown.

(2) For the RA report, if treatment using one or more technologies is part of the remedy, technology-specific unit costs should be calculated and reported in the project cost appendix. The total costs and quantities used for the calculation should be clearly stated.

(3) In the example shown in Exhibit 6-5, the subtotal RA capital costs and subtotal RA operating costs would all be considered specific to land treatment, but not projected

Cost Growth

As a project moves from the planning stage to the implementation stage, more and more becomes known about the actual costs of the project. During the course of RA projects, the expected accuracy of cost estimates ranges from about –30% to +50% for the ROD to about –10% to +15% at the time of RA bid and award to 0% at the completion of work.

Contingency is typically added to estimates at various stages to account for cost growth potential. Scope (design) contingency covers unknowns associated with an incomplete design. Bid (construction) contingency accounts for unforeseen costs that become known as construction proceeds. This amount represents a reserve for quantity overruns, modifications, change orders, claims, etc.

In addition to comparison to the ROD estimate, reporting of actual costs in the RA report allows for comparison to the bid/award estimate and assess the amount and possible causes of cost growth during implementation of the RA.

groundwater monitoring costs. As shown by the calculation in Exhibit 6-6, the unit cost for land treatment would be $33.73 per cubic yard using a total technology-specific cost of $273,247 and quantity treated of 8,100 cubic yards.

(4) For more detailed information on calculation of technology-specific unit cost, see the *Guide to Developing and Managing Cost and Performance Information for Remediation Projects* at http://www.frtr.gov/cost/.

c. HCAS Reporting. HCAS project and WBS cost breakdown forms shall be completed and included in the RA report. Exhibit 6-7 shows an example. Note that costs of project management, remedial design, construction management, and other items without WBS numbers (33 or 34 series) are not reported to HCAS.

Exhibit 6-5
Example Cost Breakdown

ACTUAL & PROJECTED COSTS (1 of 2)

Site: U Creosote Superfund Site
Location: Live Oak, Florida
Phase: Final RA Report (OU 2)
Date: October 27, 1998

Description: The selected treatment consisted of a land treatment system to remediate excavated site soils. All costs are expressed in 1998 dollars.

ACTUAL RA CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL (1998 $$)	NOTES
331XX HTRW Remedial Action					
.01 Mobilization and Preparatory Work					
.01 Mob Construction Equipment & Facilities	1	EA	$8,466	$8,466	Excavator, etc.
.03 Submittals/ Implementation Plans	1	EA	$5,350	$5,350	QAPP, SSHP, etc.
.04 Setup/Construct Temporary Facilities	1	EA	$6,602	$6,602	Roads/parking/signs, trailer
.05 Construct Temporary Utilities	1	EA	$3,716	$3,716	Electrical and water hookup
SUBTOTAL				$24,134	
.03 Sitework					
.02 Clearing and Grubbing	4.0	AC	$4,090	$16,360	Work area
.05 Fencing	7,500	LF	$2.89	$21,666	
SUBTOTAL				$38,026	
.08 Solids Collection and Containment					
.01 Contaminated Soil Excavation	8,100	CY	$0.95	$7,695	
.11 Biological Treatment					
.03 Construction of Land Treatment Unit					
.90 Installation of Clay Liner	7,000	CY	$5.70	$39,900	Impermeable layer
.91 Shaping of Retention Pond	1	EA	$5,658	$5,658	
.92 Installation of Subsurface Drainage	1	EA	$48,216	$48,216	
.93 Construction of Perimeter Berms	2,000	LF	$5.65	$11,300	
.94 Installation of Run-On Drainage Swales	3,000	LF	$1.98	$5,940	
.95 Installation of Irrigation System	1	EA	$15,802	$15,802	
.96 Rental of Tractor and Tiller	1	EA	$10,653	$10,653	
.97 Level D PPE	20	EA	$102.60	$2,052	Boots, hard hats, etc. for 20 people
SUBTOTAL				$139,521	
.20 Site Restoration					
.01 Earthwork	8,100	CY	$1.04	$8,445	Backfill, grading
SUBTOTAL				$8,445	
.21 Demobilization					
.01 Removal of Temporary Facilities	1	EA	$1,651	$1,651	Roads/parking/signs, trailer
.02 Removal of Temporary Utilities	1	EA	$929	$929	Electrical and water hookup
.04 Demob Construction Equipment & Facilities	1	EA	$2,116	$2,116	Excavator, etc.
.06 Submittals	1	EA	$4,939	$4,939	Post-const. reports
SUBTOTAL				$9,635	
SUBTOTAL				$227,456	
Project Management				18,320	
Remedial Design				34,350	
Construction Management				22,900	
TOTAL RA CAPITAL COSTS				**$303,026**	

Exhibit 6-5, cont.
Example Cost Breakdown

ACTUAL & PROJECTED COSTS (2 of 2)

ACTUAL RA OPERATING COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL (1998 $$)	NOTES
331XX HTRW Remedial Action					
.02 Monitoring, Sampling, Testing, & Analysis					
.13 Peformance Monitoring (On-Site Lab)	1	EA	$64,700	$64,700	
SUBTOTAL				$64,700	
.11 Biological Treatment					
.03 Land Treatment					
.90 Equipment Operation	1	EA	$15,232	$15,232	Sprayer and tiller
.91 Spread Soil	8,100	CY	$4.76	$38,556	Contaminated soil
.92 Maintenance/Repair	1	EA	$4,292	$4,292	Site vehicles
.93 Additional Costs	1	EA	$3,251	$3,251	Diesel fuel/fertilizer/seed cultures
SUBTOTAL				$61,331	
SUBTOTAL				$126,031	
Project Management				6,466	
TOTAL ACTUAL RA OPERATING COSTS				**$132,497**	

PROJECTED POST-RA O&M COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL (1998 $$)	NOTES
342XX HTRW Operation and Maintenance					
.02 Monitoring, Sampling, Testing, & Analysis					
.04 Groundwater Monitoring	5	EA	$4,200	$21,000	
SUBTOTAL				$21,000	
TOTAL PROJECTED POST-RA O&M COSTS				**$21,000**	

TOTAL PROJECT COST	**$456,523**

Exhibit 6-6
Example Technology-Specific Unit Cost Calculation

LAND TREATMENT	
RA CAPITAL COSTS:	
Solids Collection and Containment	$7,695
Biological Treatment	$139,521
SUBTOTAL	$147,216
RA OPERATING COSTS:	
Monitoring, Sampling, Testing, & Analysis	$64,700
Biological Treatment	$61,331
SUBTOTAL	$126,031
TOTAL TECHNOLOGY-SPECIFIC COST	$273,247
Cubic Yards of Soil Treated	8,100
TECHNOLOGY-SPECIFIC UNIT COST (Per Cubic Yard)	**$33.73**

Exhibit 6-7
Example HCAS Data Report and WBS Cost Breakdown

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 1)

Project Information

Project Name: U Creosote Operable Unit 2
Project Number: XXXX-YYYY-ZZ
Project Phase (Select one)
- Studies and Design: ____
- Remedial Action: ✓
- Operations and Maintenance: ____

Project Note (Describe the project)
Landfarming treatment technology was used to remediate 8,100 cubic yards of PAH-contaminated soil.

Contract Information

Contract Number: DACW62-97-C-0100
Managing Organization: U.S. Army Corps of Engineers
Organization Name: Jacksonville District
Site Owner: Private Party
Other ID Number: ____
Prime Contractor: Cleanup, Inc.
Contract Type (Select one)
- Cost + Award Fee: ____
- Cost + Base + Award Fee: ____
- Cost + Fixed Fee: ✓
- Cost + Incentive Award: ____
- Fixed Price: ____
- Not Availiable: ____
- Other: ____

Procurement Type (Select one)
- Two Step Sealed Bid: ____
- Sealed Bid (IFB): ____
- Competitive Negotiation (RFP): ✓
- Sole Source (SSC): ____
- Other: ____

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 2)

Site Information

State/Country	Florida/USA
Installation	
Site Name	Live Oak, FL
Site Number	
EPA Region	IV

Current Use (Select one)

Installation Operation	
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	✓
Administrative Office	
Commercial	
Other	
Unknown	

Future Use (Select one)

Installation Operation	
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	
Administrative Office	
Commercial	
Other	
Unknown	✓

Point of Contact

	Data Entry Person	POC#2	POC#3
Title/Role	Contractor Estimator		
Organization	Cleanup, Inc.		
Name	E.S. Timator		
Address	123 Main St.		
City, State	Cleantown, FL		
Zip	12345		
Telephone	999-999-9999		
Fax	999-999-8888		
Email	estimator@cleanup.com		

Enter up to 3 POC's.

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 3)

Profile - General Characteristics

Regulatory Class		Public Concern	
CERCLA	✓	Low	
RCRA		High	✓
Other		Historical/Archoelogical	
Unknown		Yes	
National Priority List		No	✓
Yes	✓	Innovative Technology	
No		Yes	
Wetland		No	✓
Yes		Size of Exclusion Zone (Acres)	4
No	✓	Size of Area (Acres)	10
Flood Plain			
Yes			
No	✓		

Profile - Contaminants/Technical Approach

Site Type	**Media**	**Contaminant**	**Technical Approach**
AG Storage Tanks	Air	Nonhal VOC's	CWM/OEW Remvl
UG Storage Tanks	Equipment/Mach	Halogenated VOC's	Surf Water Control
Drums/Cont <250 GA	Groundwater	Nonhal Semi VOC's	Grnd Water Control
Unauth Disposl Area	Liquid	Halogen Semi VOC's	Air/Gas Control
Facil/Bldgs	Surface Water	Fuels	Solids Contain
Fire Train/Open Burn	Sediment	Inorganics	Liq/Sed/Sludge Cntrl
Firing Rnge/Open Det	Sludge	Low Lev Rad Waste	Drums/Tanks Remvl
Pit/Trench	Soil	High Lev Rad Waste	Biological Treatment
Surf Impnd/Lagoons	Solid/Debris	Low Rad Mixed Wst	Chemical Treatment
Lakes/Ponds/Swamp	Struct Bldg Matls	TRU Waste	Physical Treatment
Landfill	Other	CWM/OEW	Thermal Treatment
Ocean		Asbestos	Stab/Fix/Encap
Rivers/Streams		Unknown	Decon & Decommish
Spill/Emerg Resp		Other	Disposal (Not Comm)
Waste Pile			Disposal Commercial
Other			Other

Pick as many Profile combinations as necessary:

Unauth Disp Area	Soil	Fuels	Biological Treatment

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 4)

Cost

Start Date	9/29/96
End Date	9/22/98
Number of Mods	0
Reasons for Mods (Select those applicable)	
Administrative	
Changes for Time or Cost	
Changes Requested by Government Authority	
Design Deficiency	
Differing Site Conditions	
Funding Level Change	
New Federal Regulation	
Other Changes	
Suspension or Termination of Work	
Value Engineering Change	
Variations in Estimated Quantities	
Variations Not Readily Identifiable During Design	
Cost	
Award Amount	$399,000
Actual Amount	$374,487
Cost Variance	-6%

Cost Breakdown

See next sheets.

The HCAS Cost Breakdown is structured in accordance with the February 1996 "HTRW Remedial Action Work Breakdown Structure (RA WBS)" and "HTRW O&M Work Breakdown Structure (O&M WBS)".

The next sheets show the RA WBS and O&M WBS to the Third Level as required for the HCAS cost report portion of the "RA Report".

The costs reported shall be "Burdened Costs", meaning that contractor markups, general requirements, overhead, and profit shall be included in the costs.

The complete RA WBS and O&M WBS to the Fourth Level is at:
http://www.FRTR.gov/cost/ec2/wbs1.html

The HCAS 3.1 software can be downloaded from:
http://www.FRTR.gov/cost/ec2/index.html

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number			DESCRIPTION	QTY	UOM	UNIT COST	COST $
33XXX			**HTRW CONSTRUCTION ACTIVITIES**				
331XX			**HTRW REMEDIAL ACTION (Capital and Operating)**				
	01		**MOBILIZATION AND PREPARATORY WORK**				
	01	01	Mobilization of Construction Equipment and Facilities	1	EA	8,466	8,466
	01	02	Mobilization of Personnel		EA		
	01	03	Submittals/Implementation Plans	1	EA	5,350	5,350
	01	04	Setup/Construct Temporary Facilities	1	EA	6,602	6,602
	01	05	Construct Temporary Utilities	1	EA	3,716	3,716
	01	06	Temporary Relocations of Roads/Structures/Utilities		EA		
	01	07	Construction Plant Erection		EA		
	01	08	Institutional Controls		EA		
	01	09	Alternate Water Supply		EA		
	01	10	Population Relocation		EA		
	01	9X	Other (Use Numbers 90-99)				
	02		**MONITORING, SAMPLING, TESTING, AND ANALYSIS**				
	02	01	Meteorological Monitoring		EA		
	02	02	Radiation Monitoring		EA		
	02	03	Air Monitoring and Sampling		EA		
	02	04	Monitoring Wells		EA		
	02	05	Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06	Sampling Soil and Sediment		EA		
	02	07	Sampling Asbestos		EA		
	02	08	Sampling Radioactive Contaminated Media		EA		
	02	09	Laboratory Chemical Analysis		EA		
	02	10	Radioactive Waste Analysis		EA		
	02	11	Geotechnical Testing		EA		
	02	12	Geotechnical Instrumentation		EA		
	02	13	On-Site Laboratory Facilities	1	EA	64,700	64,700
	02	14	Off-Site Laboratory Facilities		EA		
	02	9X	Other (Use Numbers 90-99)				
	03		**SITEWORK**				
	03	01	Demolition		SY		
	03	02	Clearing and Grubbing	4	ACR	4,090	16,360
	03	03	Earthwork		CY		
	03	04	Roads/Parking/Curbs/Walks		SY		
	03	05	Fencing	7500	LF	2.89	21,666
	03	06	Electrical Distribution		LF		
	03	07	Telephone/Communication Distribution		LF		
	03	08	Water/Sewer/Gas Distribution		LF		
	03	09	Steam and Condensate Distribution		LF		
	03	10	Fuel Line Distribution		LF		
	03	11	Storm Drainage/Subdrainage		LF		
	03	12	Permanent Cover Structure Over Containment Area		SF		
	03	13	Development of Borrow Pit/Haul Roads		ACR		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	03	14		Fuel Storage Tanks (New)		EA		
	03	9X		Other (Use Numbers 90-99)				
	04			**ORDNANCE AND EXPLOSIVE - CHEMICAL WARFARE**				
	04	01		Ordnance Removal and Destruction		ACR		
	04	9x		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF		
	05	02		Floodwalls		SF		
	05	03		Levees		LF		
	05	04		Terraces and Benches		LF		
	05	05		Channels/Waterways (Soil/Rock)		LF		
	05	06		Chutes or Flumes		LF		
	05	07		Sediment Barriers		LF		
	05	08		Storm Drainage		LF		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	12		Earthwork		CY		
	05	13		Erosion Control		ACR		
	05	14		Development of Borrow Pit/Haul Roads		ACR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA		
	06	02		Subsurface Drainage/Collection		LF		
	06	03		Slurry Walls		SF		
	06	04		Grout Curtain		SF		
	06	05		Sheet Piling		SF		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	09		Development of Borrow Pit/Haul Roads		ACR		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF		
	07	02		Gas/Vapor Collection Well System		EA		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection	8,100	CY	0.95	7,695
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asphalt		ACR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	07		Development of Borrow Pit/Haul Roads		ACR		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Pump System		ACR		
	09	08		Development of Borrow Pit/Haul Roads		ACR		
	09	9x		Other (Use Numbers 90-99)				
	10			**DRUMS/TANKS/STRUCTURES/MISCELLANEOUS**				
	10	01		Drum Removal		EA		
	10	02		Tank Removal		EA		
	10	03		Structure Removal		SF		
	10	04		Asbestos Abatement		SF		
	10	05		Piping and Pipeline Removal		LF		
	10	06		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	10	07		Miscellaneous Items		ACR		
	10	08		Contaminated Paint Removal		SF		
	10	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Sequencing Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)	8,100	CY	24.80	200,852
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Construction of Permanent Plant Facility		EA		
	11	9x		Other (Use Numbers 90-99)				

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	**12**			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic Oxidation, UV Ozone,		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process (BCDP)		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Construction of Permanent Plant Facility		EA		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		
	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction		CY		
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging		MGA		
	13	50		Construction of Permanent Plant Facility		EA		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Construction of Permanent Plant Facility		EA		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		
	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Construction of Permanent Plant Facility		EA		
	15	9x		Other (Use Numbers 90-99)				
	16			**RESERVED FOR FUTURE USE**				
	17			**DECONTAMINATION AND DECOMMISSIONING (D&D)**				
	17	01		Pre-Decommissioning Operations		SF		
	17	02		Facility Shutdown Activities		SF		
	17	03		Procurement of Equipment and Material		SF		
	17	04		Dismantling Activities		SF		
	17	05		Research and Development (R&D)		SF		
	17	06		Spent Fuel Handling		SF		
	17	07		Hot Cell Cleanup		SF		
	17	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Construction of Permanent Disposal Facility		EA		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees and Taxes		TON		
	18	23		Mixed Waste Storage Fees and Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	19			**DISPOSAL (COMMERCIAL)**				
	19	20		Container Handling		EA		
	19	21		Transportation to Storage/Disposal Facility		TON		
	19	22		Disposal Fees and Taxes		TON		
	19	23		Mixed Waste Storage Fees and Taxes		TON		
	19	9x		Other (Use Numbers 90-99)				
	20			**SITE RESTORATION**				
	20	01		Earthwork	8,100	CY	1.04	8,445
	20	02		Permanent Markers		EA		
	20	03		Permanent Features		EA		
	20	04		Revegetation and Planting		ACR		
	20	05		Removal of Barriers		EA		
	20	9x		Other (Use Numbers 90-99)				
	21			**DEMOBILIZATION**				
	21	01		Removal of Temporary Facilities	1	EA	1,651	1,651
	21	02		Removal of Temporary Utilities	1	EA	929	929
	21	03		Final Decontamination		EA		
	21	04		Demobilization of Construction Equipment and Facilities	1	EA	2,116	2,116
	21	05		Demobilization of Personnel		EA		
	21	06		Submittals	1	EA	4,939	4,939
	21	07		Construction Plant Takedown		EA		
	21	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				353,487

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
34XXX				**HTRW POST CONSTRUCTION AND FINANCIAL CLOSEOUT ACTIVITIES**				
341XX				**FISCAL/FINANCIAL CLOSE ACTIVITIES**				
342XX				**HTRW OPERATION AND MAINTENANCE (POST CONSTRUCTION)**				
	02			**MONITORING, SAMPLING, TESTING, AND**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling		EA		
	02	04		Monitoring Wells	5	EA	4,200	21,000
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing		EA		
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-site Laboratory Facilities		EA		
	02	14		Off-site Laboratory Facilities		EA		
	02	9X		Other (Use Numbers 90-99)		EA		
	03			**SITEWORK**				
	03	04		Roads/Parking/Curbs/Walks		SY/YR		
	03	05		Fencing		LF/YR		
	03	06		Electrical Distribution		LF/YR		
	03	07		Telephone/Communication Distribution		LF/YR		
	03	08		Water/Sewer/Gas Distribution		LF/YR		
	03	09		Steam and Condensate Distribution		LF/YR		
	03	10		Fuel Line Distribution		LF/YR		
	03	11		Storm Drainage/Subdrainage		LF/YR		
	03	12		Permanent Cover Structure Over Contaminated Area		SF/YR		
	03	14		Fuel Storage Tanks (New)		EA/YR		
	03	9X		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF/YR		
	05	02		Floodwalls		SF/YR		
	05	03		Levees		LF/YR		
	05	04		Terraces and Benches		LF/YR		
	05	05		Channels/Waterways (Soil/Rock)		LF/YR		
	05	06		Chutes or Flumes		LF/YR		
	05	07		Sediment Barriers		LF/YR		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	05	08		Storm Drainage		LF/YR		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	13		Erosion Control		ACR/YR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA/YR		
	06	02		Subsurface Drainage/Collection		LF/YR		
	06	03		Slurry Walls		SF/YR		
	06	04		Grout Curtain		SF/YR		
	06	05		Sheet Piling		SF/YR		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF/YR		
	07	02		Gas/Vapor Collection Well System		EA/YR		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY/YR		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR/YR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		
	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asph		ACR/YR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND CONTAINMENT**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	09	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Seq Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting (Soil Pile Bioremediation)		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	11	9x		Other (Use Numbers 90-99)				
	12			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic)		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis (UV Oxidation)		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction		CY		
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		
	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging		MGA		
	13	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		

Exhibit 6-7, cont.
Example HCAS Data Report and WBS Cost Breakdown

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	15	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		
	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Post Construction O&M of Permanent Disposal Fac		EA/YR		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees & Taxes		TON		
	18	23		Mixed Waste Storage Fees & Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				21,000

APPENDIX A
GLOSSARY OF ENVIRONMENTAL RESTORATION TERMS

The following definitions were taken primarily from *Superfund/Oil Program Implementation Manual FY 2001, Appendix B: Response Actions* (OSWER Publication 9200.3-14-1F-P).

Cleanup Goals Achieved This measure is used to indicate when cleanup goals have been achieved for groundwater and surface water restoration, including monitored natural attenuation. It is necessary to track achievement of cleanup goals for these remedies because the goals will not have been achieved at the time that remedial action (RA) has been completed. Cleanup Goals Achieved has been accomplished once the final RA report has been approved in writing.

Feasibility Study The primary objective of a feasibility study (FS) is to ensure that appropriate remedial alternatives are developed and evaluated such that an appropriate remedy may be selected. A FS involves the identification and detailed evaluation of potential remedial alternatives. This process begins with the formulation of viable alternatives, which involves defining remediation objectives/cleanup goals, general response actions, volumes or area of media to be addressed, and potentially applicable technologies. Following a preliminary screening of alternatives, a reasonable number of appropriate alternatives undergo a detailed analysis using the nine evaluation criteria in the National Contingency Plan (NCP). During a remedial investigation/feasibility study (RI/FS), information is gathered to support an informed decision regarding the remedy (if any) that is most appropriate for a given site or an operable unit within a site. Interim or early actions to initiate risk reduction activities can be undertaken throughout the RI/FS process.

Long-Term Response Action Long-term response action (LTRA) is defined as the Fund-financed operation of groundwater and surface water restoration measures, including monitored natural attenuation, for the first ten years of restoration. The Fund continues to pay up to 90 percent of the costs during the LTRA period, then the State funds the entire operation after the ten year period has expired. LTRA begins on the date that the designated Regional official approves the interim RA report in writing. LTRA is complete after 10 years, after a technical impracticability determination has been made, or after cleanup goals have been achieved and documented in a final RA report, whichever occurs first. LTRA transitions to O&M if cleanup goals have not been achieved, or if continued monitoring will be required, once ten years have expired. The term LTRA does not apply to groundwater and surface water restoration measures conducted under other financing mechanisms, groundwater or surface water containment measures, groundwater or surface water measures initiated for the primary purpose of providing a safe drinking water supply, or groundwater monitoring.

Natural Resource Trustees

Natural Resource Trustees are authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to assist EPA in characterizing the nature and extent of site-related contamination and impacts. The Trustees also act on behalf of the public to determine whether environmental restoration is needed in light of the response actions at a given site.

Operable Unit

The NCP defines an operable unit (OU) as a "discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of a release, or pathway of exposure" (NCP §300.5). Hence, an OU can be a certain geographic portion of a site or can address an environmental medium at the site (e.g., groundwater, soil). OUs may also be comprehensive but temporary remedies (e.g., temporary caps across a site) that provide interim protection of human health and the environment before final remediation. The cleanup of a site can be divided into a number of OUs, depending on the complexity of the problems associated with the site.

Operational and Functional

For many sites, the completion of RA also marks the completion of the operational and functional (O&F) period. O&F activities are conducted after physical construction of the remedy is complete to ensure that it is functioning properly and operating as designed. The NCP provides a maximum timeframe of one year for performing O&F activities; however, EPA may extend the one-year period, as appropriate. O&F activities may be conducted for containment, groundwater restoration, and surface water restoration remedies in order to ensure that the remedy functions properly and operates as designed. Monitored natural attenuation remedies do not go through an O&F determination. The O&F period is part of the RA and occurs during the last year of the RA. Formal O&F determinations are made primarily for Fund-financed projects, since O&F governs when O&M or LTRA begins. O&F is considered complete on the date that the designated Regional official approves the interim RA report (for sites with groundwater or surface water restoration remedies) or final RA report in writing.

Operation and Maintenance

Operation and maintenance (O&M) are the activities required to maintain the effectiveness or the integrity of the remedy. In the case of Fund-financed measures, O&M activities are required to restore groundwater or surface waters, and to continue the operation of such measures beyond the LTRA period until the cleanup goals have been achieved. Except for Fund-financed groundwater or surface water restoration actions covered under NCP §300.435(f)(4), O&M measures are initiated after the remedy has achieved the remediation objectives and/or cleanup goals listed in the ROD, and the remedy has been determined to be O&F. O&M typically starts on the date that the designated Regional official approves the final

RA report. In the case of Fund-financed LTRA that continues for a full ten years without achieving the cleanup goals, O&M starts upon completion of LTRA. In the case of Federal facility-lead groundwater and surface water restorations, including monitored natural attenuation, O&M starts on the date that the designated Regional official approves the interim RA report in writing. O&M completion is defined, where appropriate, as the date that the remediation objectives/cleanup goals or conditions specified has been met with respect to O&M. O&M may be completed when the cleanup goals have been achieved, or it may be indefinite, as in the case of a landfill cap.

Potentially Responsible Party Under CERCLA §104, a person or entity potentially responsible for a release of hazardous substances, pollutants, or contaminants into the environment (i.e., a potentially responsible party [PRP]), may also be allowed to conduct certain response actions in accordance with CERCLA §122, if the lead agency determines that party is qualified and otherwise capable. For a PRP-lead RI/FS response action, either EPA or the State serves as the lead agency and oversees the PRP's work and development of the proposed plan and the ROD. The lead agency determines whether the PRP, or the PRP's contractor, is qualified and capable of doing the work. PRPs may participate in the remedy selection process by submitting comments on the proposed plan or other information contained in the administrative record file during the formal public comment period that is held before the final remedy selection. However, PRPs generally should not be permitted to write proposed plans, RODs, or any amendments to those.

Potentially Responsible Party Long-Term Response Potentially responsible party long-term response (PRP LR) is a type of O&M. In the past, the term LTRA has been used to describe PRP-lead groundwater and surface water restoration measures, including monitored natural attenuation. However, PRP-lead groundwater and surface water restoration measures, including monitored natural attenuation, are covered by a separate action, PRP LR. Because PRP LR is a specific type of O&M, the ten-year timeframe does not apply. LTRA begins on the date that the designated Regional official approves the interim RA report in writing. PRP LR is complete after a technical impracticability determination has been made, or cleanup goals have been achieved and documented in a final RA report, whichever occurs first. The term PRP LR does not apply to groundwater and surface water restoration measures conducted under other leads, to groundwater or surface water containment measures, groundwater or surface water measures initiated for the primary purpose of providing a safe drinking water supply, or to groundwater monitoring.

Record of Decision The record of decision (ROD) documents the remedy selection and the RA plan for a site or an operable unit and serves the following three basic functions: it certifies that the remedy selection process was carried out in accordance with CERCLA and with the NCP; it describes the technical parameters of the remedy, specifying the methods selected to protect human health and the environment including treatment, engineering, and institutional control components, as well as remediation objectives/cleanup goals; and, it provides the public with a consolidated summary of information about the site and the chosen remedy, including the rationale behind the selection. While the ROD should provide a comprehensive description of site conditions, the scope of the action, the selected remedy, remediation objectives/cleanup goals, and the reason for selecting the remedy, it is only one part of the administrative record file, which contains the full details of site characterization, alternatives evaluation, and remedy selection.

Regional Contingency Plan Each EPA Region is responsible for developing regional contingency plans "to coordinate timely, effective response by various Federal agencies and other organizations to discharges of oil or releases of hazardous substances, pollutants, or contaminants" (40 CFR 300.210 (b)). Each plan includes information on facilities and resources within the Region that may be useful in responses. To the extent possible, regional contingency plans must follow the format of the NCP and be coordinated with the appropriate state emergency response plans.

Remedial Action A remedial action (RA) is the implementation of the remedy selected in the ROD. A RA is complete when the remediation objectives and/or cleanup goals stated in the ROD have been achieved, and the remedy has been determined to be O&F.

Remedial Design Remedial design (RD) is an engineering phase during which additional technical information and data identified are incorporated into technical drawings and specifications developed for the subsequent RA. These specifications are based on the detailed description of the selected remedy and on the remediation/cleanup criteria provided in the ROD.

Remedial Investigation A remedial investigation (RI) involves collecting the data necessary to adequately characterize the site for the purpose of developing and evaluating effective remedial alternatives. In general, the RI consists of the following actions: determining the nature and extent of the contamination at the site or operable unit; assessing risks to human health and the environment from this contamination; and, conducting treatability tests to evaluate the potential performance and cost of the treatment technologies being considered to address these risks. In characterizing the site, the lead agency or PRP identifies the source of contamination, the potential routes of migration, and the current and the potential human and environmental receptors. During a RI/ FS, information is gathered to support an informed decision regarding the remedy (if any) that is most appropriate for a given site or an operable unit within a site. Interim or early actions to initiate risk reduction activities can be undertaken throughout the RI/FS process.

Revised Model CERCLA RD/RA Consent Decree

The Revised Model CERCLA RD/RA Consent Decree, published July 1995, superseded the 1991 interim model. The Model Consent Decree serves as a template for binding settlement agreements that serve as determinations of responsibility under CERCLA and the NCP.

APPENDIX B
EXAMPLE REMEDIAL ACTION REPORT – EX SITU SOIL REMEDIATION

NOTE:

The following example remedial action report is based on an actual Superfund site, but some information has been altered to illustrate the concepts of the guide. In addition, names have been changed to avoid confusion with the actual site.

Content and format of actual RA reports may vary from this example due to considerations such as project lead and support roles, availability of information, and site-specific conditions. The information presented in this example report (e.g., costs) should not necessarily be used as a technical basis for completing remedial action at an actual site (e.g., as a source of cost information).

FINAL
REMEDIAL ACTION REPORT

SLIPPERY CHEMICAL SUPERFUND SITE, OPERABLE UNIT 3
GREASE, TEXAS

September 2000

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Abstract

Operable Unit 3
On-Site Thermal Treatment
Slippery Chemical Superfund Site, Grease, Texas

Site Name and Operable Unit:	Slippery Chemical Superfund Site, Operable Unit 3
Location:	Grease, Texas
Regulatory Oversight:	U.S. Environmental Protection Agency Region VI Texas Natural Resources Conservation Commission
Contractor Oversight:	U.S. Army Corps of Engineers, Ft. Worth District
Remedial Action Contractor:	H&S Consultants, Grease, TX
Waste Source:	Two lined and two unlined waste management lagoons; disposal of drums of chemical waste, chemical sludge and demolition debris on the ground surface and in the shallow subsurface
Contaminants:	Organic Compounds • 470 to 1,500,000 µg/kg ß-Naphthylamine • 3.8 to 8,200 µg/kg Fenac • Halogenated and non-halogenated VOCs and SVOCs detected in soil
Technology:	On-Site Incineration • The incineration system consisted of a co-current, rotary kiln and a secondary combustion chamber (SCC). • The kiln operated at an exit gas temperature above 1599°F and the SCC operated above 1801°F. • Hot gases exiting the SCC passed through an evaporative cooler, a baghouse, a Venturi quench unit, and a caustic scrubber. • Excavated soil was dried and screened to remove oversized organic and inorganic debris. • Excavated soil and shredded combustible material were fed to the incinerator. • Treated soil and fly ash were stockpiled for compliance sampling. • Treated soil and fly ash that met treatment standards were used as fill material at the site.
Cleanup Type:	Full-Scale
Purpose/Significance Of Application:	Remediation designed to provide permanent destruction of soil contaminants; no long-term waste management requirements following on-site backfill of incinerator ash.
Type/Quantity of Media Treated:	295,087 tons (194,520 cubic yards) of contaminated soil Moisture content: 17.6% average, range of 10 to 25.5% BTU value: 274 Btu/lb
Period of Operation:	Trial burn: 1/25/97 to 2/4/97 Full-scale operation: 3/4/98 to 4/22/99

Abstract

Operable Unit 3, cont.
On-Site Thermal Treatment
Slippery Chemical Superfund Site, Grease, Texas

Regulatory Requirements/ Cleanup Goals:

Destruction and removal efficiency (DRE) of 99.99% for POHC.
Treated soil objectives were 55 mg/kg for b-Naphthylamine and 1,000 mg/kg for Fenac.
Treated soil and fly ash with TCLP concentrations in excess 25 times the drinking water standard for any one of eight metals were stabilized.
Air emission requirements included control of metals, hydrogen chloride, total dioxins and furans, carbon monoxide, nitrous oxides, and particulate matter in the stack gas.

Results:

Sampling of treated soil indicated that the cleanup goals were met. Three percent of the soil required re-treatment to achieve cleanup levels.
Two batches of fly ash required stabilization prior to on-site backfill.
Emissions data from the trial burn and full-scale operations indicated that all emissions standards were met.

Costs:

The total cost for this project was $134,622,950, with RA capital costs of $64,676,100, RA operating costs of $69,890,000, and RA periodic costs of $56,850. The total technology-specific cost was $109,190,500. Therefore, using a quantity of 194,520 cubic yards, the technology-specific unit cost was calculated at $478 per cubic yard.

Description:

The SCS Site included a chemical manufacturing facility that operated from 1951 to 1982, producing chemical intermediates used in dye, cosmetic, textile, pharmaceutical, pesticide and herbicide manufacturing. Two lined wastewater treatment lagoons, a dry unlined sludge lagoon, and an unlined leachate lagoon were constructed at the site during the late 1950s, probably for use as waste impoundments. Drums of chemical waste, chemical sludge, and demolition debris were disposed on the ground surface and in the shallow subsurface at the site.

Site soil and chemical sludge were contaminated with VOCs, SVOCs including b-naphthylamine, the herbicide Fenac, and metals. These compounds were detected throughout the site regardless of sampling depth. A ROD was signed in September 1988, specifying on-site incineration as the remedial technology for addressing soil contamination at the site. Contaminated soil/sludge/sediment and groundwater were identified as Operable Unit (OU) 3.

Site work for construction of the incinerator commenced in April 1995. Incinerator shake down and a clean burn were conducted in January 1996. The incinerator was then shut down until September 1996 due to a lawsuit filed to stop the remediation project. System optimization and preliminary testing were conducted in the Fall of 1996. The trial burn and risk burns were conducted in January and February 1997. Following approval of the test results, the incinerator was put into full-scale operation in March 1998. All site soil was excavated down to the water table (about 15 feet below ground surface) and treated. The total area of the SCS Site is 9.6 acres. The incineration system consisted of a co-current, rotary kiln followed by a SCC. After confirming that treated soil and fly ash met the cleanup criteria, the materials were backfilled at the site. Treatment was completed in April 1999.

SITE DESCRIPTION

The Slippery Chemical Superfund (SCS) Site is located in Slick County, Texas, in the city of Grease. The site was a chemical manufacturing facility that operated from 1951 to 1982. During its operation, the Slippery Chemical Company produced chemical intermediates used in dye, cosmetic, textile, pharmaceutical, pesticide and herbicide manufacturing. The total area of the site is 9.6 acres and includes the previous location of the Slippery Chemical Company and the adjacent Oily Chemical Company property. Figure 1 shows the general layout of the site.

The Slippery Chemical plant included several major buildings, two lined wastewater treatment lagoons, a dry unlined sludge lagoon, and an unlined leachate lagoon. The lagoons were constructed during the late 1950s, probably for use as waste impoundments. The leachate lagoon was constructed in the lowest portion of the site, and is assumed to be the collection point for all surface runoff at the site. Approximately 60 process tanks and reactors were located inside and surrounding the process buildings. Approximately 10 additional larger tanks were staged outside of the buildings for bulk storage of acids, bases, and fuel oils.

The area surrounding the site includes the Oily Chemical Company to the west, Rough Paper Company to the southwest, Wet Creek to the south, the west branch of the Roaring River to the north, and an apartment complex and shopping center to the east.

GEOLOGY AND STRATIGRAPHY

The general lithology of the upper 15 feet of overburden material at the SCS Site consists of sandy clay floodplain deposits with various lenses of clay dispersed throughout. Below approximately 15 feet, the alluvial sediments increase in grain size with increasing depth to sand and gravel and then to sand with gravel and cobble-sized sandstone fragments. The bedrock is a soft gray to shaley claystone and medium hard limestone ranging from less than 1 foot to 31 feet in thickness, and occurs at approximately 110 feet bgs.

Groundwater at the SCS Site flows to the north, east and south. Local groundwater flows to the south and southeast toward Wet Creek. Groundwater is typically encountered at 12 to 15 feet bgs.

RELEVANT OPERATIONS AND WASTE MANAGEMENT PRACTICES

From the late 1950s through the early 1980s, four waste management lagoons (waste impoundments) were operated at the SCS Site. The two wastewater lagoons were lined, but the sludge lagoon and leachate lagoon were unlined. Additionally, drums of chemical waste, chemical sludge, and demolition debris were disposed on the ground surface and in the shallow subsurface at the site.

REGULATORY HISTORY

Slippery Chemical was cited many times by state and federal agencies for violating environmental and health and safety regulations. In 1982, after Slippery Chemical failed to respond to the U.S. Environmental Protection Agency's (USEPA's) request to clean up the site, the USEPA initiated an emergency removal action during which drums, surface sludges, and storage tanks were removed. During this removal action, USEPA removed 1,700 exposed drums and drained and neutralized approximately 10 large tanks used for bulk storage of acids, bases, and fuel oil. Access to the site was controlled using an 8-foot fence, and warning signs were posted.

A Superfund remedial investigation and feasibility study (RI/FS) was initiated in 1983. The first two phases of the RI/FS led to interim remedial actions, specifically: Operable Unit (OU) -1 – the remediation of a leachate stream that was discharging to an off-site area; and OU-2 – the removal of the two lined wastewater treatment lagoons and the on-site structures. Phase I was completed in 1987. Phase II was completed in 1988.

The September 1988 Record of Decision (ROD) addressed both soil/sludge/sediment contamination and groundwater contamination at the SCS site; however, OU-3, the subject of this report, only addresses soil/sludge/sediment.

The Phase III RI/FS was initiated in January 1987. During Phase III field investigations, samples of soil, groundwater, surface water and sediment were collected. Forty-one test pits were excavated to characterize contaminated soil and sludge at the site. Each test pit was excavated to the water table or to a depth of 15 feet below ground surface (bgs), whichever was more shallow.

NATURE AND EXTENT OF CONTAMINATION

During the Phase III RI/FS, soil, groundwater, surface water, and sediment contamination was observed throughout the site. OU-3 addressed all of these contaminated media. The degree of contamination varied throughout the study area. In general, the frequency of occurrence and concentrations of contaminants were greatest on the Slippery Chemical property and immediately off-site, particularly on the Oily Chemical property, which is located immediately north of the Slippery Chemical property. Based on local groundwater patterns, the Oily Chemical property is considered to be down gradient of the Slippery Chemical Property.

Chemical sludge and contaminated soil were observed in all of the open area on the SCS Site. The soil and sludge were contaminated with volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), Fenac, β-naphthylamine, and metals. Organic contaminants (i.e., Fenac) were consistently observed in samples collected throughout the site. Field screening revealed that the vadose zone at the site was contaminated to varying concentrations with chlorinated solvents and benzene, toluene, ethylbenzene, and xylenes (BTEX). Substituted chlorinated phenols and alkyl phenols were also present. These compounds occurred throughout the site regardless of sampling depth; therefore, no one particular area of the Slippery Chemical property or the adjacent Oily Chemical property could have been considered the most likely source of contamination. Metals were also detected in soil samples; however, it is not clear whether activities at the Slippery Chemical plant were the source of metals contamination.

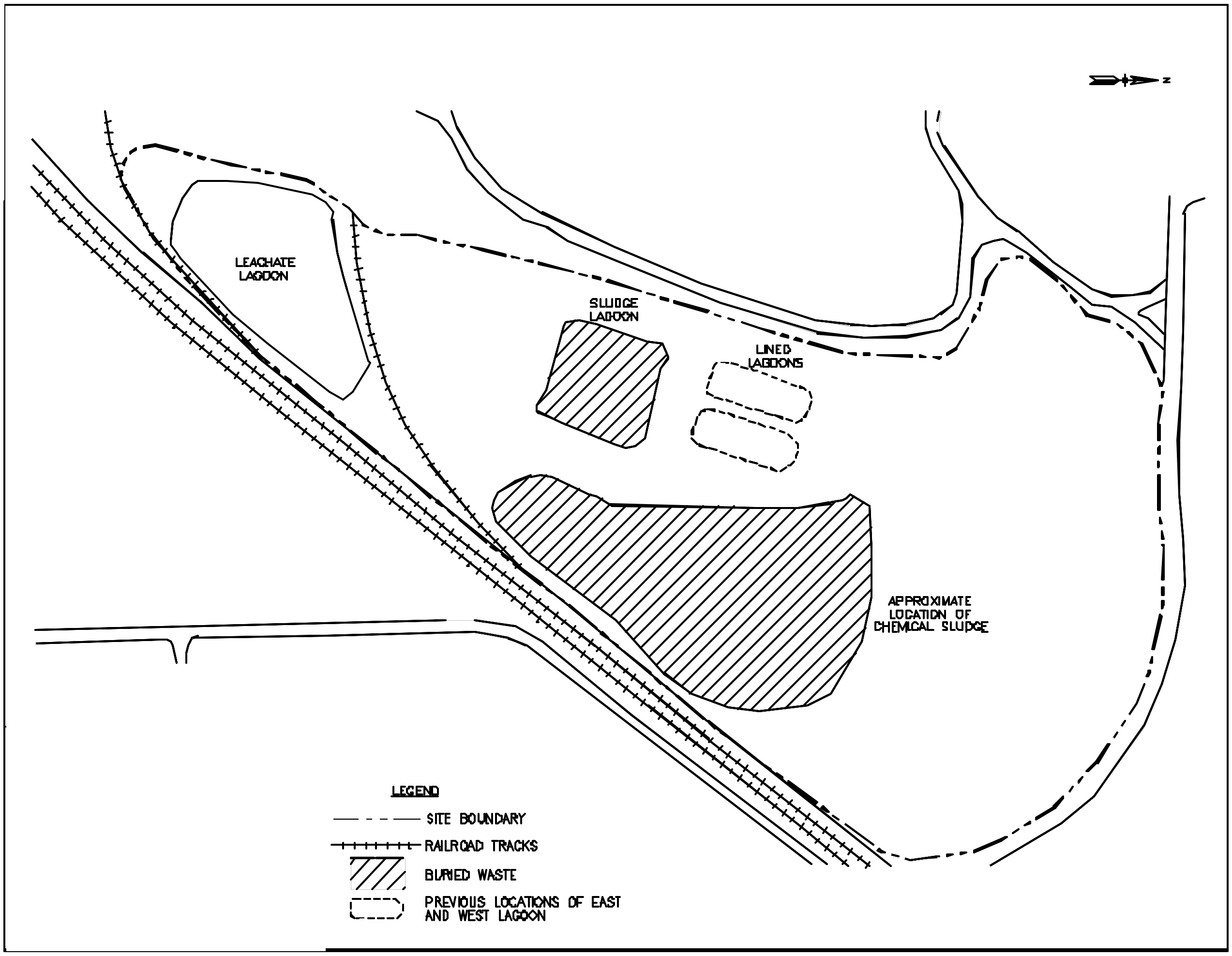

FIGURE 1
SLIPPERY CHEMICAL SUPERFUND SITE

REMEDY SELECTION

Based upon CERCLA requirements and a detailed analysis of the alternatives, USEPA and the Texas Natural Resources Conservation Commission (TNRCC) recommended incineration of all soil and buried waste within the SCS Site boundary down to the groundwater table. The selected remedy was deemed:

- To be protective of human health and the environment,
- To meet all applicable or relevant and appropriate federal and state requirements (ARARs), and
- To be cost-effective.

This remedy satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility or volume as a principal element and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable.

The selected remedy for the SCS Site included:

- Excavation of approximately 252,000 cubic yards (CY) of contaminated sludge, soil, and sediments,
- Treatment of excavated materials in an on-site mobile rotary kiln incinerator,
- Backfilling all excavations (potentially with incinerator ash), and
- Installation of a vegetative cover.

CLEANUP GOALS/STANDARDS

The following table lists the remediation objectives for soil treated in the incinerator operated at the SCS Site. These objectives were established in the September 1988 ROD to meet TNRCC requirements.

Treated Soil Objectives

Contaminant	Cleanup Level (mg/kg)
Volatile Organics	
Benzene	100
Chlorobenzene	10,000
1,2-Dichloroethene	7,000
Ethylbenzene	70,000
Tetrachloroethane	2,000
Toluene	100,000
Trichloroethene	2,000

Contaminant	Cleanup Level (mg/kg)
Total Xylenes	5,000
Semivolatile Organics	
Benzo(a)anthracene	6,000
Benzo(b)fluoranthene	6,000
Benzo(k)fluoranthene	60,000
Benzoic Acid	3,300
Benzo(a)pyrene	660
Chrysene	300,000
1,2-Dichlorobenzene	7,000
1,4-Dichlorobenzene	8,000
Fluoranthene	400,000
Naphthalene	8,000
Pentachlorophenol	40,000
Phenanthrene	80,000
Phenol	400,000
Pyrene	300,000
1,2,4-Trichlorobenzene	20,000
β-Naphthylamine	55
Chlorinated Herbicide	
Fenac	1,000

CONSTRUCTION AND IMPLEMENTATION OF THE TREATMENT REMEDY

A background air monitoring study was performed prior to on-site construction activities. The study was conducted from October 10 through December 5, 1994. The perimeter air monitoring program was initiated in March 1995, and excavation began in April 1995. In order to support the vertical excavation at the site boundaries, a sheet pile excavation support system was installed to allow "straight cut" excavations. Soil excavation was the first step in incinerator construction, and the unit was sited on imported clean fill placed after the initial excavation. Construction of the incineration system was completed in December 1995. System shakedown and a clean burn were conducted on January 13, 1996. The incinerator was then shut down until September 23, 1996 due to a lawsuit that was filed by a local opposition group against the USEPA to stop the remediation project. Approval to continue the project was issued on August 14, 1996.

A mobile, on-site incineration system was used to decontaminate soil, sludge, and sediment at the SCS Site. The incineration system consisted of a rotary kiln, a secondary combustion chamber (SCC), and an air pollution control system (APCS). Rotary kiln incinerators are able to process a wide variety of waste feed compositions and handle oversized wastes with minimal processing pre-treatment. The rotary kiln portion of the system is used to volatilize and destroy the majority of the organic contaminants. The remaining organic contaminants exit the kiln with the hot gases into the SCC where additional destruction occurs. The APCS is used to provide particulate matter and acid gas control. Figure 2 shows a schematic of the on-site incineration system.

Site characteristics, operating limits, and operating parameters of the incineration system are presented in Appendix A. The system was operated using the following steps:

- Contaminated soil was excavated down to the water table over the entire site and was dried by adding cement kiln dust or lime. Soil was then transported to the debris separation building. Material greater than 4 inches in diameter was removed from the soil by rotating barrel screens and underwent manual segregation into organic and inorganic debris. Organic debris (e.g., wood) was shredded. Inorganic debris was either landfilled (e.g., plastic), recycled (e.g., steel) or cleaned for backfill (e.g., rocks). Material less than 4 inches in diameter was stockpiled in the feed preparation building after ferrous material was electromagnetically removed.

- Soil was blended with shredded brush, roots, trees, and other combustible material. The soil was fed onto a variable-speed, apron conveyor, a weigh belt conveyor, and into the kiln feed hopper. Feed material was delivered from the hopper to the kiln via dual, water-cooled, feed screws. The feed material was sampled and analyzed for metals, SVOCs (including β-naphthylamine), VOCs, Fenac, and physical/chemical parameters (e.g., BTU, moisture, ash, and chlorine).

- The rotary kiln was 60 feet long and had an inside diameter of 11 feet. The kiln was operated concurrently with the waste feed located at the same end as the oxygen-natural gas burners.

Contaminated soil traveled through the kiln via gravity. The kiln was operated at a minimum exit gas temperature of 1599°F.

- The kiln discharge chamber was sized to reduce the flue gas velocity and remove large particulate matter in the exit gas stream. The hot gas cyclone subsequently removed additional particulate matter in the flue gas prior to entering the SCC. The SCC was operated at a minimum temperature of 1801°F and a minimum gas retention time of 2 seconds.

- Exhaust gases from the SCC were cooled to 400°F using air-atomized, water spray nozzles in an evaporative cooler. The cooled flue gases then passed through a baghouse for removal of particulate matter. The baghouse was designed with a 3-to-1 air-to-cloth ratio.

- The baghouse gas discharged to an induced draft (ID) fan, which drew gases through the entire system and discharged them through the wet scrubber system to the discharge stack. The fan produced negative pressure throughout the incineration system to eliminate fugitive emissions.

- Exhaust gases from the baghouse were cooled from approximately 350°F to 185°F with water sprays in the Venturi quench unit. A mildly caustic scrubber water solution neutralized dissolved acid gases in one of two countercurrent, packed-bed absorbers, which were operated in parallel. The pH of the scrubber water was maintained between 6.5 and 9 by addition of a sodium hydroxide solution. The cleaned gas passed through a high-efficiency, multi-pass mist eliminator for removal of entrained water droplets.

- Cleaned flue gas was exhausted through a 150-foot tall stack equipped with continuous emission monitors (CEMs) that analyzed the gas for oxygen (O_2), carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbons (THC), and nitrogen oxides (NO_x).

- Bottom ash and fly ash were segregated prior to disposal. Bottom ash consisted of treated soil from the kiln and ash collected by the cyclone and SCC. Fly ash consisted of ash from the evaporative cooler and baghouse. Each ash stream was cooled and wetted by spraying with excess scrubber system water, after which it was conveyed to the ash storage area. A 10,000 cubic feet per minute (cfm) scrubber and Lamella clarifier system captured steam issuing from the wet ash drag conveyor to prevent off-site migration of particulate matter.

- Fly was were tested for TCLP metals as each storage bin was filled. Each day’s production of bottom ash was separated for testing of TCLP metals, Fenac, SVOCs (including b-naphthylamine), and VOCs. Ash failing the cleanup criteria was retreated. Ash meeting the cleanup criteria was backfilled on-site. Ash with TCLP concentrations greater than 25 times any of the drinking water standards was stabilized prior to backfill.

In addition to the incineration system, a 100-gallon per minute (gpm) wastewater treatment plant (WWTP) was installed and operated at the site to remove metals and organic compounds from various water streams generated during the project. Treated wastewater was discharged to Wet Creek. Wastewater treated at the WWTP included: incineration system pad cleaning water; ash handling pad cleaning water; wash water from equipment and personnel decontamination activities; water collected from the leachate lagoon; water collected from the soil excavation cavities; and potentially-contaminated storm water. The WWTP included the following treatment technologies:

- Primary settling;
- Wastewater equalization tanks;
- Metals removal through chemical addition, flocculation, and clarification;
- Neutralization;
- Sand filtration for suspended solids removal;
- Air stripping with activated carbon columns for treating organics transferred to the air stream;
- Bag filtration for removal of small-diameter suspended solids;
- Activated carbon adsorption for removal of residual organics; and
- Sludge dewatering with a filter press.

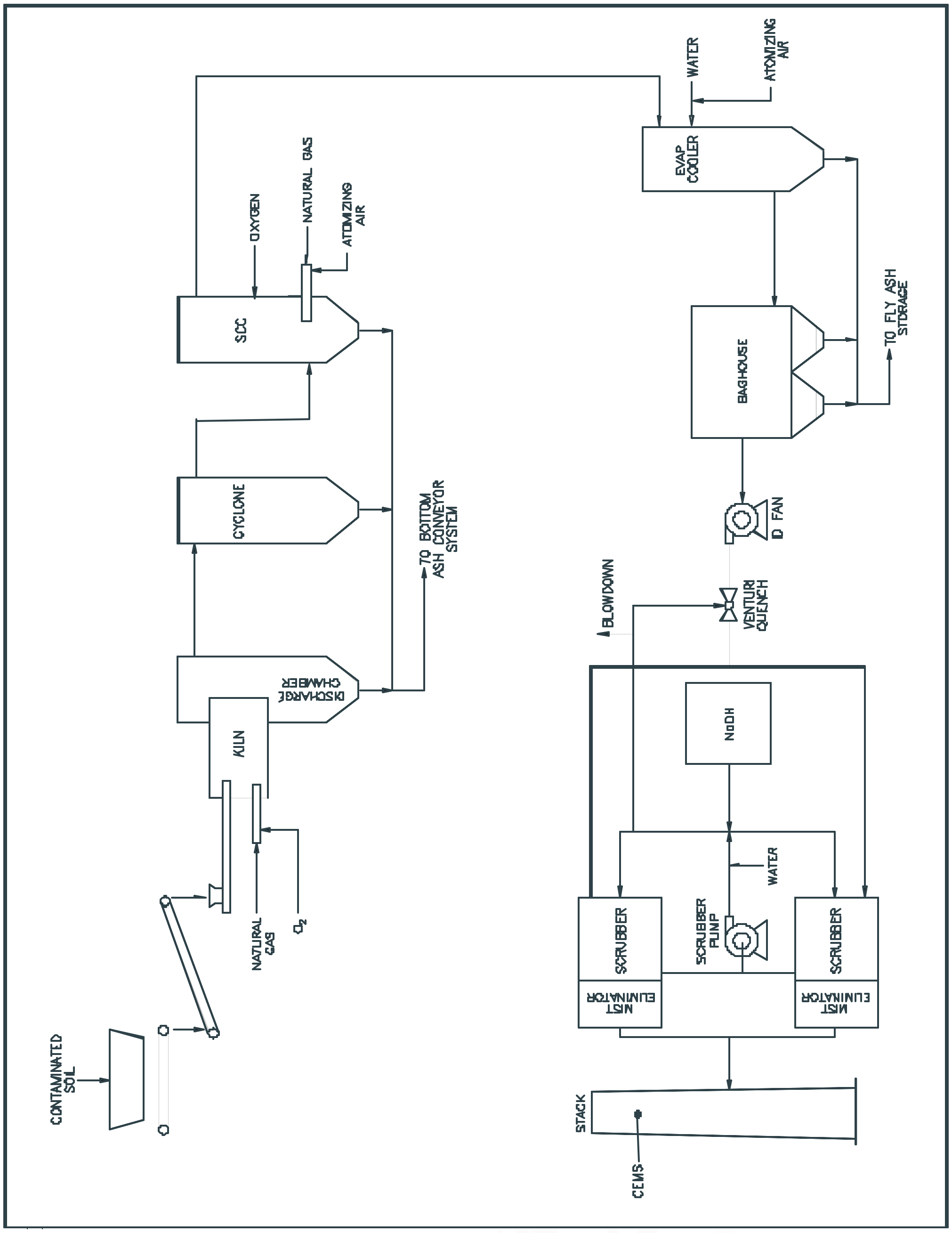

FIGURE 2
SCHEMATIC DIAGRAM OF THE SITE INCINERATOR

The following table includes the dates of the most significant events in the operation of the incinerator system and WWTP at the SCS site.

Date	Activity
September 29, 1988	Phase III ROD signed by the U.S. EPA and the Army
Spring 1989	Phase II remediation completed
October 1990 – August 1991	Incineration feasibility study conducted
September 30, 1993	Contract awarded
November 15, 1993	Notice to proceed issued
November 14, 1994	Mobilization to the site
May 13, 1995	WWTP put into operation
January 3, 1996	Construction of incinerator and supporting facilities complete
January 13, 1996	Shakedown and clean burn complete
January 14, 1996 – August 14, 1996	Stop work in effect due to lawsuit
September 19, 1996	Public meeting held on the revised trial burn risk assessment protocol
January 20 – 22, 1997	Risk Burn No. 1 conducted
January 25 – February 4, 1997	Trial Burn conducted
February 7 – 9, 1997	Risk Burn No. 2 conducted
February 10, 1997 – March 4, 1998	Project shutdown for risk and trial burn data review
February 10, 1998	Public meeting held on the risk assessment
March 9, 1998	Full-scale operations started
April 22, 1999	Soil incineration completed
November 23, 1999	Project completion

PERFORMANCE STANDARDS

The following table provides the performance objectives that were established for the SCS Site incinerator in the September 1988 ROD:

Incinerator Performance Objectives

Parameter	Performance Criteria
Principal Organic Hazardous Constituent (POHC) destruction removal efficiency (DRE)	≥ 99.99%
Particulate Matter (PM) Emissions	≤0.01 grains/dry standard cubic foot (gr/dscf) @ 7% O_2
Hydrochloric Acid (HCl) Emissions	≤4 lb/hr or 99% reduction
Total Dioxins and Furans Emissions	≤30 nanograms/dry standard cubic meter (ng/dscm) @ 7% O_2
NO_x Emissions	≤300 parts per million – volume (ppmv) @ 7% O_2 (daily average)
CO Emissions	≤100 ppmv @ 7% O_2 (hourly rolling average)
Metal Emissions As Be Cd Cr^{+6} Cr Pb	 <0.11 g/sec <0.20 g/sec <0.27 g/sec <0.04 g/sec <0.12 g/sec <1,384 g/sec

Fly ash and bottom ash were analyzed for metals using the toxicity characteristic leaching procedure (TCLP). The results were compared to the Texas drinking water standards listed in the table below. Ash meeting these standards could be backfilled on-site without restriction. Ash failing these standards, but with TCLP concentrations less than 25 times the drinking water standards, could be returned to the site as fill material but could not be placed below 553 feet mean sea level (8 feet above the average water table). As specified in the 1988 ROD, treated soil with TCLP concentrations greater than 25 times the drinking water standard required stabilization prior to backfill.

Ash TCLP Concentration Objectives

Metal	Drinking Water Standard (mg/L)	25 x Standard (mg/L)
Arsenic	0.05	1.25
Barium	1.0	25
Cadmium	0.01	0.25
Chromium	0.05	1.25
Lead	0.05	1.25
Mercury	0.002	0.05
Selenium	0.01	0.25
Silver	0.05	1.25

As discussed previously, perimeter air monitoring was routinely performed at the site. Three VOCs were selected as key indicator compounds to be monitored by the HNu if the average NMOC reading exceeded 1 parts per million (ppm). Perimeter action levels were set at 10% of the OSHA permissible exposure limits (PELs) for each of the three selected contaminants. The perimeter action levels were:

- 9.146 ppm for toluene
- 7.777 ppm for chlorobenzene
- 2.511 ppm for tetrachloroethene

The table below provides the discharge limitations for the WWTP at the SCS Site as specified in the September 1988 ROD. Weekly samples of the WWTP effluent were required whenever the WWTP was in operation.

Wastewater Discharge Limitations

Parameter	Monthly Average (mg/L)	Daily Maximum (mg/L)
β-Naphthylamine	0.012	0.024
Fenac	0.100	0.200
Toluene	0.010	0.020
Chlorobenzene	0.010	0.020
1,2-Dichlorobenzene	0.010	0.020
1,4-Dichlorobenzene	0.010	0.020
1,2-Dichloroethane	0.010	0.020
Trichloroethene	0.005	0.010
Total Arsenic	0.100	0.200
Total Barium	2.000	4.000
Total Cadmium	0.060	0.120
Total Nickel	0.200	0.400
Total Chromium	0.150	0.300
Total Lead	1.000	2.000
pH	6 to 9 standard units	6 to 9 standard units

QUALITY ASSURANCE AND QUALITY CONTROL

Data Assessment

An incineration feasibility study was conducted between October 1990 and August 1991. All test runs met the cleanup criteria established for the SCS Site. The pilot-scale rotary kiln incinerator achieved 99.99% destruction removal efficiency (DRE) of Principal Organic Hazardous Constituents (POHCs), which were spiked into the soil. The leachable metal concentrations in the ash from the pilot study were either non-detect or were below TCLP limits for characteristic hazardous waste, so no fixation or stabilization was required prior to backfilling incinerator ash on site. Some fly ash had TCLP metal concentrations above the drinking water standards.

A risk assessment concluded that full-scale operation of the incinerator at the SCS Site would not pose a threat to public health. All of the estimated risks were within the range that is considered acceptable for cleanup activities performed under the Superfund hazardous waste program.

The results from the trial burn demonstrated that the incinerator met the RCRA performance standards of 40 CFR 264 and other regulatory and contractual requirements while burning site soils spiked with POHCs and metals.

During full-scale operations, all treated soil batches met the cleanup criteria for Fenac after the first pass; eight treated soil batches did not initially meet the cleanup goal for β-naphthylamine. Of the total mass of soil treated, less than 3% required additional thermal treatment after the first pass. Soil not meeting the cleanup criteria was sent back to the feed preparation building where it was blended with the other soil, and then conveyed to the incinerator.

TCLP metals results for 2 batches of fly ash were greater than 25 times the drinking water standard (once during a metals spiking test and the other time during full-scale operation). The fly ash from these batches was stabilized prior to backfill.

Stack testing, perimeter air monitoring and ambient air monitoring performed in the community near the project site met all specified objectives.

Data Quality

All trial burn testing was conducted in accordance with the source test sampling and analysis protocols specified in the quality assurance plan for the trial burn. All data gathered during the trial burn were found to be of acceptable quality to demonstrate that the incinerator met the performance standards. The quality assurance/quality control (QA/QC) results were compared to the data quality objectives specified in the Project Quality Assurance Plan contained in the Trial Burn Plan. This comparison showed that greater than 90% of the accuracy, precision, and method performance objectives were met.

The perimeter air sampling and off-site ambient air sampling were conducted in accordance with the SCS Site Perimeter Air Sampling Plan, including the calibration, sampling and analytical procedures. Other sampling and analysis activities during full-scale operations (e.g., soil and ash tests) were conducted according to the protocols in the Chemical Quality Management Sampling Plan.

INSPECTIONS

The project utilized the U.S. Army Corps of Engineers (USACE) Three Phase Inspection Program which included the Preparatory Inspection – prior to the start of work, Initial Inspection – as soon as representative portion of the work was complete, and Follow Up Inspection – daily until the work is complete. Prior to site mobilization a list of the Definable Features of Work was generated. The Definable Features of Work list was a guideline for initiating the Three Phase Inspection Program on individual work tasks. The Definable Features of Work list was updated monthly and forwarded to the USACE for information only.

CERTIFICATIONS

As part of the submittal process data, drawings, instructions, schedules, statements, reports, certificates, samples, and records were transmitted to the USACE for either review and action or for information only. Each individual submittal was given a unique transmittal number. Submittals were forwarded to the USACE on Government Form SF4025 and to other reviewers such as the USACE Architectural Engineer, USEPA, and TNRCC on Government Form SF4026. Submittals were tracked in the Complete Submittal Register that was updated on a monthly basis. A copy of all submittals was kept on file at the project site.

The Quality Control Department was responsible for generating a Daily Contractors Quality Control Report (DCQCR). Starting with mobilization, through the contract completion date, a DCQCR was generated and issued for each contract day. The report included the following information: date, report number corresponding to the number of contract days, general weather information, work performed by H&S Consultants, attachment reports, work performed by subcontractors, inspections performed, testing performed, verbal instructions received from Government personnel, verbal instructions received from Government personnel on construction deficiencies, safety violations observed, remarks, and worker hours and equipment use. Two copies of the report (one with the original H&S Consultants QC signature) were forwarded to the USACE QA Field Office.

Data Quality Objectives (DQOs) were established prior to the start of the project and were updated throughout the project. Individual programs such as the Perimeter Air Sampling Program and the Chemical Quality Management/Sampling Program defined DQOs. Objectives included precision, accuracy, representativeness, comparability, and completeness. In 1997, a process to consolidate the DQOs was performed. The result was a document that defined DQOs for all chemical data generated on the project. The DQOs were summarized using a seven step process outlined in EPA's "Guidance for the Data Quality Objectives Process" (1994).

HEALTH AND SAFETY

A Permea-Tec® pad was used to verify that beta-napthylamine (BNA) had not permeated gloves and protective clothing during usage. To use this method as a field verification of chemical protective gloves, a worker wore a pad on the back of the hand over the top of the inner glove and beneath the outer glove for approximately two hours. After wear, the outer glove was removed and the Permea-Tec® pad was retrieved. The analysis of the pad was activated with tap water. A positive indication of breakthrough of 2-naphthlylamine (2-NA) through the personal protective equipment (PPE) would result in a predominately red color change of the pad. During the course of the project, no positive results were found with the 780 separate pad tests collected.

A Surface Swype® pad was also used to determine surface contamination of aromatic amine compounds. A monthly wipe sampling program using these pads was implemented to confirm that support areas were not becoming contaminated during site activities. During the course of the project, no positive results were found from the 627 Surface Swype® samples collected in trailers and support facilities.

Surface Swype® pads were also used to confirm that equipment, which had entered the exclusion zone, was decontaminated of aromatic amines prior to release from the exclusion zone. During the equipment decontamination program, only three of the 2,864 pads showed the characteristic color change indicating the presence of aromatic amines. Of the three positive samples, one was found to be a false positive through additional testing and research, and the other two were equipment which were re-cleaned using a decontamination solution formulated to remove aromatic amine compounds. After re-cleaning with the decontamination solution, the equipment Surface Swype® was repeated and no color change was indicated.

Another type of pad utilized was a Skin Swype® pad. The Skin Swype® pad was used to determine that no inadvertent skin contamination with 2-NA had occurred. When a worker exited the exclusion zone, the worker’s skin was wiped with a Skin Swype® pad prior to washing, the pad was placed in a small cup containing developing solution, the developing solution was allowed to wick through the pad. If a strip near the top of the pad changed color, it was considered to be positive for an aromatic amine. None of the 770 Skin Swype® pads showed a positive result.

The Risk Assessment Report and associated risk analysis were complete in January 1998, at which time the USACE notified H&S Consultants to prepare for the operation phase. In late February 1998, a clean burn demonstration was performed to ensure that the thermal destruction facility (TDF) was mechanically capable of performing during the Operations Phase. On March 4th, with the clean burn successfully complete, and with concurrence from USEPA and USACE, the Operation Phase commenced.

With-in several days of the Operation Phase concerns were raised over whether dust was entrained in the steam generated from the thermal process and whether, if entrained, it was leaving the site boundary. Several members of the project team including USEPA, TNRCC, USACE, and H&S Consultants inspected the process and determined that there was no dust leaving the site boundary, but that modifications could be made to help alleviate the dust concern. The first effort was to install a hood equipped with mist spray nozzles on the ash-receiving bin. The use of mist nozzles in the ash-receiving bin knocked out dust that was entrained in the steam. The second effort was to partially enclose the fly ash building. This allowed additional residence time in the building for steam to settle. The first two efforts were implemented immediately. The third effort included locating a steam scrubber that could be installed as final precaution to scrub the steam of any entrained dust. By the end of April 1998, a steam scrubber was mobilized to the site, modified for the site-specific application, and installed in the ash-receiving bin.

In early April 1998, after preliminary kiln refractory brick repairs failed, a decision was made to re-line the kiln with a castable refractory. Installation of the new refractory took place during the last three weeks of April and the first week of May. The Operation Phase resumed during the first week of May 1998.

As per the TNRCC Air Equivalency Document and the Trial Burn Plan, Operation Phase Stack Testing was performed. Once per month for the first three months of operations stack testing was performed for dioxin and Furan analysis. Once per quarter for the duration of the project stack testing was performed for particulate and metals analysis.

During the Operation Phase several statistical operating goals were established. A “utilization percentage” was calculated to illustrate performance of the TDF as compared to a benchmark operating rate of 47 tons per hour. A “utilization average” was calculated to summarize the performance of the TDF. An “availability percentage” was calculated to illustrate the time the TDF was physically available to operate. An “availability average daily tons” was calculated to summarize the TDF production during available operating hours. An “availability TPH” was calculated to summarize the TDF production rate during available operating hours. The percentage of ash requiring additional thermal treatment was calculated and compared to a project goal. The following table summarizes the Operation Phase performance versus established goals.

Operation Phase Performance

Parameter	Goal	Achieved
Utilization %	86.0%	75.0%
Utilization Avg. TPH	40.4 TPH	35.3 TPH
Availability %	71.0%	78.1%
Availability Avg. Daily Tons	688.8 Tons	660.7
Availability TPH	28.7 TPH	27.53 TPH
Ash Req. Add. Thermal Treat	5%	2.7%

The Operation Phase was complete on April 22nd, 1999 when the final soil to be incinerated was fed to the TDF. Final bottom ash analytical results were received on April 23, at which time the TDF burners were shut off and the Demobilization Phase started.

PROCUREMENT PROCESS

USACE awarded the contract to perform the soil remediation at OU-3 to Remedial Services International on September 30, 1993, with remediation activities performed by Remedial Services International. Remedial Services International was subsequently acquired by H&S Consultants, which was later acquired by ABC Corporation. The contract was awarded using a firm fixed-price cost structure. On September 23, 1996, the contract was converted to a cost plus fixed fee contract.

TREATMENT SYSTEM COST

The table below summarizes total project costs for the RA at OU 3. Appendix B provides a breakdown of these costs.

Cost Item	Adjusted ROD Estimate	Actual Cost[1]	Difference[2]
RA Capital Costs (1994-1999)	$78,150,000	$64,676,100	- 17 %
RA Operating Costs (1998-1999)[3]	$45,800,000	69,890,000	+ 53 %
RA Periodic Costs (1999)	$45,000	56,850	+ 26 %
Total Costs Incurred, Years 0-5 (Actual $$)	$123,995,000	$134,622,950	+ 9 %

[1] Costs are based on the respective years that the costs were incurred. The ROD estimates were adjusted from 1988 dollars to the appropriate year's dollar basis using ENR building cost index factors.

[2] Differences between the actual RA operating costs and the adjusted ROD estimate are largely attributable to the waiting phase associated with a project shutdown pending the outcome of a lawsuit filed by a citizens group ($14,268,000). Costs were saved during site restoration by using clean, excavated rock as backfill and by eliminating the need for vegetative cover (see Section 9 for additional information).

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COST-RELATED

Costs on similar future projects could be reduced by taking preliminary steps to minimize the chances for shutdowns caused by legal actions. Millions of dollars in costs were incurred while the incinerator was shutdown pending the outcome of a lawsuit brought by an opposition group.

A significant cost savings was realized due to a change incorporated into the contract specifications allowing for the cleaning and backfilling of excavated rock. The reuse of rock eliminated costs associated with importing stone from an outside source.

The initial remedial design included laying cover material capable of supporting vegetation over treated soil depleted of organic material. Two studies demonstrated that the addition of compost and fertilizer to the treated soil would be sufficient to allow sustained growth of a vegetative cover. The amended design resulted in elimination of costs associated with importing fill materials and topsoil.

PERFORMANCE-RELATED

Project managers of future similar projects should perform a thorough review of the proposed equipment layout plans. Equipment locations are particularly important to consider with material handling systems. Bins and buildings to store and/or stabilize ash should be located in close proximity to ash sources to minimize the amount of high wear/severe duty equipment (e.g., screw augers and drag conveyors) necessary.

The feed preparation area should be as large as physically possible to allow sufficient room for any additional equipment, which may become necessary for trash separation, drum handling operations, pre-drying and similar operations.

Dust suppression is an important aspect of managing soil and ash on-site. When possible, soil and ash management operations should be conducted within an enclosed structure such as a building under slight negative pressure or using enclosed equipment.

During the preliminary site investigation and incinerator conceptual design, the moisture content of site soil should be characterized. Worst case moisture content should be included in the RFP so the contractor design engineers can size the kiln and burners accordingly. Soil moisture will greatly affect the allowable throughput rate and the ability of the system to remove contaminants from the soil. A heat transfer specialist should do a thorough review of the assumptions and calculations used to size the incineration equipment.

The temperature of the treated soil exiting the kiln is a primary indicator of whether the soil will meet the treatment requirements. The contractor should measure the kiln exit soil temperatures to obtain a real-time indication of the kiln efficiency, rather than waiting 72 hours for the analytical results of the treated soil samples.

Due to the severe environments under which they operate, the ash conveyance system may be particularly susceptible to mechanical failure. A thorough review of the contractor's proposed system should be performed. The review should draw upon the vast quantity of material handling information and experience available within the combustion industry.

Whenever cost and space allow, redundant systems should be implemented in order to keep the incinerator operational. The incinerator cannot physically operate without certain systems online (e.g., drag conveyors or pumps) and the incinerator must not be allowed to operate if certain equipment is not operational per permit requirements (e.g., Continuous Emission Monitors [CEMs]). Incinerator downtime can be costly because site personnel must be paid and equipment rental fees are incurred whether the incinerator is operating or not.

Performing a clean burn prior to feeding hazardous waste to the incinerator can have the following benefits:

- Serves as a mechanical shakedown of the system;
- Provides an opportunity to do performance testing on the CEMs; and
- Provides an opportunity to debug any programming or control systems without the risk of any sort of a release or labor-intensive decontamination prior to correcting any problems.

During the incinerator optimization stage and the trial burn tests, the incinerator should be operated under a wide range of operating conditions (e.g., varied feed rate, kiln rotation speed, and combustion temperature) to ensure that the permit limits allow the desired level of operating flexibility.

OTHER LESSONS LEARNED

The USACE and the state regulatory agency were involved with a proactive, USEPA-lead public relations effort that was implemented from the beginning of the project. This was achieved by developing a public relations plan in conjunction with the local community.

Ninety to one hundred twenty days was allowed for state review of permit equivalency documents, including the Trial Burn Plan.

The RFP specifications delineated which activities were construction-related and which activities were service-related. Difficulties can arise when personnel working side-by-side on the same equipment are paid different wages.

Staffing requirements for an incineration project are greater than the typical USACE construction project. Required staff included an on-site project chemist, thermal incineration experts, office engineers, project engineers, quality assurance staff, and an on-site authorized contracting officer’s representative. In addition, the contracting officer’s representative was given more authority to process changes so the changes could be incorporated in a timely manner.

A Construction Management Plan was developed that included the roles and responsibilities of the participating organizations and individuals.

The project manager prepared for the worst weather possible at the site. Freezing pipes, power outages, late deliveries, inability to move equipment and excavations filling with water are examples of weather-related problems. These occurrences, if not anticipated, could have delayed the project and been a source of additional costs.

Local emergency responders were involved with emergency response planning and drills. They were provided with the required training and the necessary response equipment if they were not already prepared for incinerator-related emergencies.

All pertinent federal and state regulations and guidance documents identified in the project specifications were available on-site for reference.

Due to the large volume of information gathered and shared with outside agencies, a computer-based information and issue tracking system was used for this project. The system contained complete descriptions of the issues, responsible individuals, inception dates, and anticipated resolution dates. The system was reviewed on a regular basis to track the status of outstanding issues.

Before initiating site work, a cost-benefit analysis was performed to determine if a backup to the primary laboratory should be selected. Selection of a backup laboratory at the beginning of the project eliminated time spent for laboratory validation and approval, which could have impacted the project in progress if a laboratory had not been selected prior to start of work.

An active safety incentive program increased worker safety awareness and reduced injuries and accidents.

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19. Stan Bopp, USACE, Final Cost Report, Slippery Chemical Superfund Site, April 21, 2000.

The table below lists selected characteristics for the soil at the SCS Site. Except where noted, data provided are average values for pre-treatment soil samples collected during the 1997 trial burns.

Site Characteristics

Characteristic	Value	Measurement Procedure
Soil Classification[1]	SM (silty sands and silt-sand mixtures)	USCS
Clay Content[1]	3.8 to 8.8%	ASTM D422
Moisture Content	16%[2]	ASTM D-3173
Total Petroleum Hydrocarbon (TPH) Content	181 to 6,569 mg/kg	EPA 418.1
Bulk Density	99.8 to 109.6 lbs/ft^3	ASTM D 4253 and 4254
BTU Value	274 BTU/lb	ASTM D 2015
Halogen Content	260 mg/kg Chlorine	ASTM E 442 or D 808/D 4327
Metal Content Arsenic Beryllium Cadmium Chromium Lead	 7.65 mg/kg 0.67 mg/kg 0.16 mg/kg 24.5 mg/kg 41.6 mg/kg	 ICP ICP ICP, GFAA ICP ICP

[1] These data correspond to treated soil samples. Data was not available for untreated soil.

[2] During full-scale operations, the soil moisture content ranged from 10.0 to 25.5% and averaged 17.6%.

The following table lists the operating limits for the incineration system that were approved by the USEPA and TNRCC prior to full-scale operation of the system. These operating limits were developed based on the results of the trial burns and risk burns.

Operating Limits

Parameter	Value
Waste Feed Rate, Maximum Allowable	47.3 tons/hr rolling average
Kiln Hood Pressure, Maximum Allowable	0 inches water column (wc) instantaneous -0.1 inches wc for 10 seconds or more
Kiln Exit Temperature, Minimum Allowable	1599ºF hourly average 1000ºF instantaneous
Kiln Exit Temperature, Maximum Allowable	2200ºF
Kiln Rotation, Minimum Allowable	0.4 revolutions per minute (rpm)
SCC Temperature, Minimum Allowable	1801ºF
SCC Temperature, Maximum Allowable	2600ºF
SCC Residence Time, Minimum Allowable	2 seconds
Baghouse Inlet Temperature, Maximum Allowable	500ºF
Baghouse Air-to-Cloth ratio, Maximum Allowable	3.6 to 1
Bag House Pressure Drop, Minimum Allowable	1.0 inches wc for more than 5 minutes

Parameter	Value
Bag House Pressure Drop, Maximum Allowable	6 inches wc for more than 5 minutes
Scrubber Inlet Temperature, Maximum Allowable	250ºF
Scrubber Liquid pH, Minimum Allowable	6.5
Scrubber Liquid Feed Rate, Minimum Allowable	450 gallons per minute (gpm) hourly average
CO Emissions, Maximum Allowable	200 parts per million by volume (ppmv) instantaneous 100 ppmv hourly rolling average
NO_x Emissions, Maximum Allowable	300 ppmv daily average
Stack Gas Velocity, Maximum Allowable	46.2 ft/sec hourly average

The table below lists values for selected parameters observed during incineration operations at OU-3. Observed values are compared to design values for each parameter. The parameters were selected for this report based on USACE guidance. Data provided are based on average conditions during full-scale operation of the incinerator system.

Operating Parameters

System Parameter	Design Value	Actual Value
Residence Time (Air in SCC)	>2 seconds	1.7 to 4.6 seconds
Residence Time (Soil in Kiln)	30 minutes	24.6 to 44.3 minutes
System Throughput	60 ton/hr	40.4 tons/hr (average)
Flue Gas Temperature	Information not available Information not available	>1599 °F (kiln) >1801 °F (SCC)

APPENDIX B — Project Costs

The following tables present a breakdown of actual costs incurred for the project and calculation of technology-specific unit cost for incineration. HCAS data entry sheets are also attached to this appendix.

ACTUAL COSTS (1 of 2)

Site: Slippery Chemical Site
Location: Grease, Texas
Phase: Final RA Report (OU-3)
Date: June 7, 1999

Description: The selected treatment consisted of a mobile rotary kiln incinerator used to treat excavated sludge, soil and sediments onsite. In addition, a waste water treatment plant (WWTP) used granular activated carbon (GAC) to treat all water produced from the excavation and incineration processes.

RA CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL (1994 $$)	NOTES
331XX HTRW Remedial Action					
.01 Mobilization and Preparatory Work					
.02 Mob of Personnel	1	EA	$3,171,000	$3,171,000	
.03 Submittals/ Implementation Plans	1	EA	$2.683.000	$2.683.000	
.04 Setup/Construct Temporary Facilities	1	EA	$2.665.000	$2.665.000	Fence, roads/parking, signs, trailers
.05 Construct Temporary Utilities	1	EA	$122.000	$122.000	
SUBTOTAL				$8.641.000	
.03 Sitework					
.08 Water/Sewer Relocation	2.425	LF	$378	$916.000	
.06 Groundwater Collection					
.05 Earthwork - Sheet Piling	87,204	SF	$55	$4,809,000	
.08 Solids Collection and Containment					
.01 Contaminated Soil Excavation	194.520	CY	$15	$2.856.000	
.10 Drums/Tanks/Struct/Misc Removal					
.01 Drum Handling and Removal	185	EA	$1.157	$214.000	
.07 Debris Removal	8	AC	$39.375	$315.000	
SUBTOTAL				$529.000	
.13 Physical Treatment					
.20 Carbon Adsorption - Liquids					WWTP
.05 Mobilize/Setup/Relocate Plant	1	EA	$811.000	$811.000	
.07 Demobilize Plant	1	EA	$71.000	$71.000	
SUBTOTAL				$882.000	
.14 Thermal Treatment					
.01 Incineration					
.04 Pads/Foundations/Spill Control	39.875	SF	$48	$1.914.000	
.05 Mobilize/Setup Plant	1	EA	$4.420.000	$4.420.000	
.06 Startup/Readiness Test/Trial Burn	1	EA	$12,910,000	$12,910,000	
.07 Demobilize Plant	1	EA	$2,248,000	$2,248,000	
SUBTOTAL				$21,492,000	
.18 Disposal (Other than Commercial)					
.21 Transport to Storage/Disposal Facility	275.467	TON	$14	$3.762.000	Load/Haul/Unload
.19 Disposal (Commercial)					
.21 Transport to Storage/Disposal Facility	2.200	TON	$275	$604.000	Load/Haul/Unload
.20 Site Restoration					
.01.03 Earthwork - Backfill	194,520	CY	$13	$2,544,000	
.01.04 Earthwork - Borrow	12,376	CY	$16	$195,000	
.01.90 Grading & Topsoil	1	EA	$378.000	$378.000	
.03.90 Storm Drainage	1	EA	$245.000	$245.000	
.04 Revegetation and Planting	8	AC	$10.750	$86.000	Seeding/mulch/fertilizer
SUBTOTAL				$3.448.000	
.21 Demobilization					
.01 Removal of Temporary Facilities	1	EA	$408.000	$408.000	Fence, roads/parking, signs, trailers
.02 Removal of Temporary Utilities	1	EA	$99.000	$99.000	
.03 Final Decontamination	1	EA	$812,000	$812,000	
.04 Demobilization of Construction Equipment	1	EA	$318,000	$318,000	Excavator, etc.
SUBTOTAL				$1,637,000	
SUBTOTAL				$49.576.000	
Project Management				3.544.500	
Remedial Design				5.915.600	
Construction Management				5.640.000	
TOTAL RA CAPITAL COSTS				**$64.676.100**	

ACTUAL COSTS (2 of 2)

RA OPERATING COSTS[1]:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL (Actual $$)	NOTES
331XX HTRW Remedial Action					
.02 Monitoring, Sampling, Testing, and Analysis					
.03 Air Monitoring and Sampling (17.3 mo)	1	EA	$5,574,000	$5,574,000	HNu, Summa Cannisters, CEMs
.13 On Site Laboratory Facilities	1	EA	$211,000	$211,000	GC, MS
.14 Off Site Waste Water Analysis (17.3 mo)	1	EA	$268,000	$268,000	NPDES Compliance
SUBTOTAL				$6,053,000	
.13 Physical Treatment					
.20 Carbon Adsorption - Liquids (21,000 MGA)					WWTP
.08 Plant Operation	17.3	MO	$127,399	$2,204,000	
.14 Thermal Treatment					
.01 Incineration (194,520 CY)					
.01 Solids Preparation and Handling	194,520	CY	$17	$3,380,000	Drying, blending, feeding
.08 Ownership Plant / Plant Operation	14.2	MO	$1,027,715	$14,594,000	
.10 Performance Testing	1	EA	$11,542,000	$11,542,000	
.90 Utilities	14.2	MO	$742,324	$10,541,000	Electricity + fuel
.91 Waiting Phase	7	MO	$2,038,286	$14,268,000	
SUBTOTAL				$54,325,000	
.15 Stabilization/Fixation					
.04 Pozzolan Process	3,054	CY	$73	$223,000	
SUBTOTAL				$62,805,000	
Project Management				2,289,000	
Technical Support				4,796,000	
TOTAL RA OPERATING COSTS				**$69,890,000**	

[1] Actual costs based on the respective year the costs were incurred (i.e., 1998 and 1999).

RA PERIODIC COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL (1999 $$)	NOTES
Remedial Action Report	1	EA	$56,850	$56,850	1 report upon project completion
TOTAL RA PERIODIC COSTS				**$56,850**	

TOTAL ACTUAL RA COSTS INCURRED	**$134,622,950**

INCINERATION TECHNOLOGY-SPECIFIC UNIT COST CALCULATION	
RA CAPITAL COSTS:	
Solids Collection and Containment'	$2,856,000
Drums/Tanks/Struct/Misc Removal	$529,000
Physical Treatment	$882,000
Thermal Treatment	$21,492,000
Disposal (Other than Commercial)	$3,762,000
Disposal (Commercial)	$604,000
SUBTOTAL	$30,125,000
RA OPERATING COSTS:	
Monitoring, Sampling, Testing, and Analysis	$6,053,000
Physical Treatment	$2,204,000
Thermal Treatment	$54,325,000
Stabilization/Fixation	$223,000
SUBTOTAL	$62,805,000
TOTAL TECHNOLOGY-SPECIFIC COST	$92,930,000
Volume of Media Treated (Cubic Yards)	194,520
TECHNOLOGY-SPECIFIC UNIT COST (Per Cubic Yard)	**$478**

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 1)

Project Information

Project Name: Slippery Chemical Operable Unit 3

Project Number: ______

Project Phase (Select one)

- Studies and Design ______
- Remedial Action ✓
- Operations and Maintenance ______

Project Note (Describe the project)

Incineration treatment technology was utilized to remediate 194,520 cy of soil contaminated with VOCs, SVOCs, Fenac, Naphthylamine, etc.

Contract Information

Contract Number: DACW63-93-C-0200

Managing Organization: U.S. Army Corps of Engineers

Organization Name: Ft. Worth District

Site Owner: Private Party

Other ID Number: ______

Prime Contractor: H&S Consultants

Contract Type (Select one)

- Cost + Award Fee ______
- Cost + Base + Award Fee ______
- Cost + Fixed Fee ✓
- Cost + Incentive Award ______
- Fixed Price ______
- Not Availiable ______
- Other ______

Procurement Type (Select one)

- Two Step Sealed Bid ______
- Sealed Bid (IFB) ______
- Competitive Negotiation (RFP) ✓
- Sole Source (SSC) ______
- Other ______

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 2)

Site Information

State/Country	Texas/USA
Installation	
Site Name	Grease, TX
Site Number	
EPA Region	VI

Current Use (Select one)

Installation Operation	
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	✓
Administrative Office	
Commercial	
Other	
Unknown	

Future Use (Select one)

Installation Operation	
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	
Administrative Office	
Commercial	
Other	
Unknown	✓

Point of Contact

	Data Entry Person	POC#2	POC#3
Title/Role	Contractor Estimator		
Organization	H&S Consultants		
Name	John Jones		
Address	630 Hilton St.		
City, State	Grease, TX		
Zip	99990		
Telephone	555-555-4102		
Fax	555-555-4103		
Email	jjones@h&s.com		

Enter up to 3 POC's.

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 3)

Profile - General Characteristics

Regulatory Class			Public Concern	
	CERCLA	✓	Low	
	RCRA		High	✓
	Other		Historical/Archoelogical	
	Unknown		Yes	
National Priority List			No	✓
	Yes	✓	Innovative Technology	
	No		Yes	
Wetland			No	✓
	Yes		Size of Exclusion Zone (Acres)	9.6
	No	✓	Size of Area (Acres)	9.6
Flood Plain				
	Yes			
	No	✓		

Profile - Contaminants/Technical Approach

Site Type	**Media**	**Contaminant**	**Technical Approach**
AG Storage Tanks	Air	Nonhal VOC's	CWM/OEW Remvl
UG Storage Tanks	Equipment/Mach	Halogenated VOC's	Surf Water Control
Drums/Cont <250 GA	Groundwater	Nonhal Semi VOC's	Grnd Water Control
Unauth Disposl Area	Liquid	Halogen Semi VOC's	Air/Gas Control
Facil/Bldgs	Surface Water	Fuels	Solids Contain
Fire Train/Open Burn	Sediment	Inorganics	Liq/Sed/Sludge Cntrl
Firing Rnge/Open Det	Sludge	Low Lev Rad Waste	Drums/Tanks Remvl
Pit/Trench	Soil	High Lev Rad Waste	Biological Treatment
Surf Impnd/Lagoons	Solid/Debris	Low Rad Mixed Wst	Chemical Treatment
Lakes/Ponds/Swamp	Struct Bldg Matls	TRU Waste	Physical Treatment
Landfill	Other	CWM/OEW	Thermal Treatment
Ocean		Asbestos	Stab/Fix/Encap
Rivers/Streams		Unknown	Decon & Decommish
Spill/Emerg Resp		Other	Disposal (Not Comm)
Waste Pile			Disposal Commercial
Other			Other

Pick as many Profile combinations as necessary:

Surf Impnd/Lagoons	Soil	Nonhal VOCs	Thermal Treatment
Surf Impnd/Lagoons	Soil	Halogenated VOCs	Thermal Treatment
Surf Impnd/Lagoons	Soil	Nonhal SVOCs	Thermal Treatment
Surf Impnd/Lagoons	Soil	Halogenated SVOCs	Thermal Treatment

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 4)

Cost

Start Date	9/30/1993
End Date	11/23/1999
Number of Mods	0
Reasons for Mods (Select those applicable)	
Administrative	
Changes for Time or Cost	
Changes Requested by Government Authority	
Design Deficiency	
Differing Site Conditions	
Funding Level Change	
New Federal Regulation	
Other Changes	
Suspension or Termination of Work	
Value Engineering Change	
Variations in Estimated Quantities	
Variations Not Readily Identifiable During Design	
Cost	
Award Amount	$99,000,000
Actual Amount	$112,381,000
Cost Variance	+13,381,000

Cost Breakdown

See next sheets.

The HCAS Cost Breakdown is structured in accordance with the February 1996 "HTRW Remedial Action Work Breakdown Structure (RA WBS)" and "HTRW O&M Work Breakdown Structure (O&M WBS)".

The next sheets show the RA WBS and O&M WBS to the Third Level as required for the HCAS cost report portion of the "RA Report".

The costs reported shall be "Burdened Costs", meaning that contractor markups, general requirements, overhead, and profit shall be included in the costs.

The complete RA WBS and O&M WBS to the Fourth Level is at:
http://www.FRTR.gov/cost/ec2/wbs1.html

The HCAS 3.1 software can be downloaded from:
http://www.FRTR.gov/cost/ec2/index.html

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
33XXX				**HTRW CONSTRUCTION ACTIVITIES**				
331XX				**HTRW REMEDIAL ACTION (Capital and Operating)**				
	01			**MOBILIZATION AND PREPARATORY WORK**				
	01	01		Mobilization of Construction Equipment and Facilities		EA		
	01	02		Mobilization of Personnel	1	EA	3,171,000	3,171,000
	01	03		Submittals/Implementation Plans	1	EA	2,683,000	2,683,000
	01	04		Setup/Construct Temporary Facilities	1	EA	2,665,000	2,665,000
	01	05		Construct Temporary Utilities	1	EA	122,000	122,000
	01	06		Temporary Relocations of Roads/Structures/Utilities		EA		
	01	07		Construction Plant Erection		EA		
	01	08		Institutional Controls		EA		
	01	09		Alternate Water Supply		EA		
	01	10		Population Relocation		EA		
	01	9X		Other (Use Numbers 90-99)				
	02			**MONITORING, SAMPLING, TESTING, AND ANALYSIS**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling	1	EA	5,574,000	5,574,000
	02	04		Monitoring Wells		EA		
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing		EA		
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-Site Laboratory Facilities	1	EA	211,000	211,000
	02	14		Off-Site Laboratory Facilities	1	EA	268,000	268,000
	02	9X		Other (Use Numbers 90-99)				
	03			**SITEWORK**				
	03	01		Demolition		SY		
	03	02		Clearing and Grubbing		ACR		
	03	03		Earthwork		CY		
	03	04		Roads/Parking/Curbs/Walks		SY		
	03	05		Fencing		LF		
	03	06		Electrical Distribution		LF		
	03	07		Telephone/Communication Distribution		LF		
	03	08		Water/Sewer/Gas Distribution	2,425	LF	378	916,000
	03	09		Steam and Condensate Distribution		LF		
	03	10		Fuel Line Distribution		LF		
	03	11		Storm Drainage/Subdrainage		LF		
	03	12		Permanent Cover Structure Over Containment Area		SF		
	03	13		Development of Borrow Pit/Haul Roads		ACR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	03	14		Fuel Storage Tanks (New)		EA		
	03	9X		Other (Use Numbers 90-99)				
	04			**ORDNANCE AND EXPLOSIVE - CHEMICAL WARFARE**				
	04	01		Ordnance Removal and Destruction		ACR		
	04	9x		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF		
	05	02		Floodwalls		SF		
	05	03		Levees		LF		
	05	04		Terraces and Benches		LF		
	05	05		Channels/Waterways (Soil/Rock)		LF		
	05	06		Chutes or Flumes		LF		
	05	07		Sediment Barriers		LF		
	05	08		Storm Drainage		LF		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	12		Earthwork		CY		
	05	13		Erosion Control		ACR		
	05	14		Development of Borrow Pit/Haul Roads		ACR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA		
	06	02		Subsurface Drainage/Collection		LF		
	06	03		Slurry Walls		SF		
	06	04		Grout Curtain		SF		
	06	05		Sheet Piling	87,204	SF	55	4,809,000
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	09		Development of Borrow Pit/Haul Roads		ACR		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF		
	07	02		Gas/Vapor Collection Well System		EA		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection	194,520	CY	15	2,856,000
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asphalt		ACR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	07		Development of Borrow Pit/Haul Roads		ACR		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Pump System		ACR		
	09	08		Development of Borrow Pit/Haul Roads		ACR		
	09	9x		Other (Use Numbers 90-99)				
	10			**DRUMS/TANKS/STRUCTURES/MISCELLANEOUS**				
	10	01		Drum Removal	185	EA	1,157	214,000
	10	02		Tank Removal		EA		
	10	03		Structure Removal		SF		
	10	04		Asbestos Abatement		SF		
	10	05		Piping and Pipeline Removal		LF		
	10	06		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	10	07		Miscellaneous Items	8	ACR	39,375	315,000
	10	08		Contaminated Paint Removal		SF		
	10	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Sequencing Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Construction of Permanent Plant Facility		EA		
	11	9x		Other (Use Numbers 90-99)				

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	**12**			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic Oxidation, UV Ozone,		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process (BCDP)		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Construction of Permanent Plant Facility		EA		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		
	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids	21,000	MGA	146.95	3,086,000
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction		CY		
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging		MGA		
	13	50		Construction of Permanent Plant Facility		EA		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration	194,520	CY	389.76	75,817,000
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Construction of Permanent Plant Facility		EA		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		
	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)	3,054	CY	73	223,000
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Construction of Permanent Plant Facility		EA		
	15	9x		Other (Use Numbers 90-99)				
	16			**RESERVED FOR FUTURE USE**				
	17			**DECONTAMINATION AND DECOMMISSIONING (D&D)**				
	17	01		Pre-Decommissioning Operations		SF		
	17	02		Facility Shutdown Activities		SF		
	17	03		Procurement of Equipment and Material		SF		
	17	04		Dismantling Activities		SF		
	17	05		Research and Development (R&D)		SF		
	17	06		Spent Fuel Handling		SF		
	17	07		Hot Cell Cleanup		SF		
	17	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Construction of Permanent Disposal Facility		EA		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility	275,467	TON	14	3,762,000
	18	22		Disposal Fees and Taxes		TON		
	18	23		Mixed Waste Storage Fees and Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	19			**DISPOSAL (COMMERCIAL)**				
	19	20		Container Handling		EA		
	19	21		Transportation to Storage/Disposal Facility	2,200	TON	275	604,000
	19	22		Disposal Fees and Taxes		TON		
	19	23		Mixed Waste Storage Fees and Taxes		TON		
	19	9x		Other (Use Numbers 90-99)				
	20			**SITE RESTORATION**				
	20	01		Earthwork	207,896	CY	14.99	3,117,000
	20	02		Permanent Markers		EA		
	20	03		Permanent Features	1	EA	245,000	245,000
	20	04		Revegetation and Planting	8	ACR	10,750	86,000
	20	05		Removal of Barriers		EA		
	20	9x		Other (Use Numbers 90-99)				
	21			**DEMOBILIZATION**				
	21	01		Removal of Temporary Facilities	1	EA	408,000	408,000
	21	02		Removal of Temporary Utilities	1	EA	99,000	99,000
	21	03		Final Decontamination	1	EA	812,000	812,000
	21	04		Demobilization of Construction Equipment and Facilities	1	EA	318,000	318,000
	21	05		Demobilization of Personnel		EA		
	21	06		Submittals		EA		
	21	07		Construction Plant Takedown		EA		
	21	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				112,381,000

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
34XXX				**HTRW POST CONSTRUCTION AND FINANCIAL CLOSEOUT ACTIVITIES**				
341XX				**FISCAL/FINANCIAL CLOSE ACTIVITIES**				
342XX				**HTRW OPERATION AND MAINTENANCE (POST CONSTRUCTION)**				
	02			**MONITORING, SAMPLING, TESTING, AND**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling		EA		
	02	04		Monitoring Wells		EA		
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing		EA		
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-site Laboratory Facilities		EA		
	02	14		Off-site Laboratory Facilities		EA		
	02	9X		Other (Use Numbers 90-99)		EA		
	03			**SITEWORK**				
	03	04		Roads/Parking/Curbs/Walks		SY/YR		
	03	05		Fencing		LF/YR		
	03	06		Electrical Distribution		LF/YR		
	03	07		Telephone/Communication Distribution		LF/YR		
	03	08		Water/Sewer/Gas Distribution		LF/YR		
	03	09		Steam and Condensate Distribution		LF/YR		
	03	10		Fuel Line Distribution		LF/YR		
	03	11		Storm Drainage/Subdrainage		LF/YR		
	03	12		Permanent Cover Structure Over Contaminated Area		SF/YR		
	03	14		Fuel Storage Tanks (New)		EA/YR		
	03	9X		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF/YR		
	05	02		Floodwalls		SF/YR		
	05	03		Levees		LF/YR		
	05	04		Terraces and Benches		LF/YR		
	05	05		Channels/Waterways (Soil/Rock)		LF/YR		
	05	06		Chutes or Flumes		LF/YR		
	05	07		Sediment Barriers		LF/YR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	05	08		Storm Drainage		LF/YR		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	13		Erosion Control		ACR/YR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA/YR		
	06	02		Subsurface Drainage/Collection		LF/YR		
	06	03		Slurry Walls		SF/YR		
	06	04		Grout Curtain		SF/YR		
	06	05		Sheet Piling		SF/YR		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF/YR		
	07	02		Gas/Vapor Collection Well System		EA/YR		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY/YR		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR/YR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		
	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asph		ACR/YR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND CONTAINMENT**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	09	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Seq Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting (Soil Pile Bioremediation)		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	11	9x		Other (Use Numbers 90-99)				
	12			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic)		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis (UV Oxidation)		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction		CY		
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		
	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging		MGA		
	13	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	15	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		
	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Post Construction O&M of Permanent Disposal Fac		EA/YR		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees & Taxes		TON		
	18	23		Mixed Waste Storage Fees & Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
					TOTAL AMOUNT $				0

APPENDIX C
EXAMPLE REMEDIAL ACTION REPORT – IN SITU SOIL AND GROUNDWATER REMEDIATION

NOTE:

The following example remedial action report is based on an actual Superfund site, but some information has been altered to illustrate the concepts of the guide. In addition, names have been changed to avoid confusion with the actual site.

Content and format of actual RA reports may vary from this example due to considerations such as project lead and support roles, availability of information, and site-specific conditions. The information presented in this example report (e.g., costs) should not necessarily be used as a technical basis for completing remedial action at an actual site (e.g., as a source of cost information).

INTERIM
REMEDIAL ACTION REPORT

LANDFILL 5 OPERABLE UNIT

FT. GRIFFEY, OHIO

September 2000

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Landfill 5 Operable Unit
Air Sparging/Soil Vapor Extraction
Ft. Griffey, Ohio

Site Name and Operable Unit:	Landfill 5 Operable Unit
Location:	Fort Griffey, Ohio
Regulatory Oversight:	U.S. Environmental Protection Agency Region V Riverfront Air Pollution Control Agency
Contractor Oversight:	U.S. Army Corps of Engineers, Louisville District
Remedial Action Contractor:	Remediation Enhanced Developments, Inc., Cincinnati, OH
Waste Source:	Disposal of refuse and liquid waste in an unlined landfill cell during the 1950s and 1960s
Contaminants:	Dichloroethene (DCE) Trichloroethene (TCE) Tetrachloroethene (PCE) Vinyl Chloride (VC) Benzene, toluene, ethylbenzene, and xylenes (BTEX)
Technology:	Air Sparging/Soil Vapor Extraction • The full-scale system includes 5 AS wells, 6 SVE wells, 10 vadose zone piezometer (VZP) wells, and 3 dissolved oxygen sensor (DOS) wells. • An impermeable layer on the ground is used to increase the SVE wells' radii of influence. • Two parallel systems of vapor-phase granular activated carbon (GAC) are used. • SVE system operates at 0-1,290 scfm. • AS system operates at 0-210 scfm.
Cleanup Type:	Full-Scale
Purpose/Significance Of Application:	Remediation designed to treat soils suspected of being sources of groundwater contamination and to treat impacted groundwater.
Type/Quantity of Media Treated:	Approximately 60 pounds of TCE had been removed as of October 31, 1997 (based on concentrations in extracted soil gas). It is estimated that 27,800 cubic yards of soil (by SVE) and 37,400,000 gallons of groundwater (by AS) will have been treated by the end of system operation.
Period of Operation:	Pilot Test: 1/5/95 to 1/15/95 Full-Scale Operation: Ongoing
Regulatory Requirements/ Cleanup Goals:	The cleanup levels established for groundwater in the upper aquifer beneath the site are: TCE: 5 µg/L (MCL from the Federal Safe Drinking Water Act) VC: 1 µg/L (Ohio State Model Toxics Control Act Method B) Monitoring of manganese is required along the western border of South and Northwest LF5 to determine any changes in concentration. A site-specific air emission threshold limit of 2.5 parts per million volume (ppmv) TCE was also established.

Abstract

Landfill 5 Operable Unit
Air Sparging/Soil Vapor Extraction
Ft. Griffey, Ohio

Results: The concentration of TCE in the soil gas extracted by the SVE system generally decreased from 210 parts per billion by volume (ppbv) to 140 ppbv during the period of April 1, 1995 through July 27, 1995. The extracted soil gas concentration then increased to a maximum of 640 ppbv during the period of August 1, 1995 through December 27, 1999.

Costs: The total actual costs incurred for this project from Years 0-5 (1994-1999) are $1,852,104, with a capital cost of $729,294. The total project costs remaining are $2,111,483 (Years 6-15). The technology-specific unit costs for soil vapor extraction and air sparging were calculated at $65.75 per cubic yard and $18.83/1,000 gallons, respectively. These unit costs include both actual and projected costs that are applicable to each technology.

Description: Ft. Griffey occupies approximately 86,000 acres along the northern bank of the Ohio River, approximately 12 miles from Cincinnati, Ohio. Ft. Griffey began operating in 1917 and currently serves as a military reservation. Ft. Griffey is divided by I-5 into North Ft. Griffey and the Main Post.

The RI, completed in 1993 by RED, under contract with USACE, Louisville District, included an extensive landfill and soil gas survey and a groundwater investigation. The RI confirmed the presence of chlorinated hydrocarbons and aromatic hydrocarbons contamination at LF5. Elevated levels of TCE, PCE, and DCE were detected in the soil. TCE, VC and BTEX contamination was detected in the groundwater. Elevated levels of Mn were also detected in the groundwater along the western borders of South and Northwest LF5. However, the RI attributes these elevated levels to the dissolution of Mn from geologic materials in the area of LF5.

The full-scale system operation began when the startup activities were completed on July 29, 1995. The full-scale system operation is currently ongoing. The concentration of TCE in the soil gas extracted by the SVE system generally decreased from 210 parts per billion by volume (ppbv) to 140 ppbv during the period of April 1, 1995 through July 27, 1995. The extracted soil gas concentration then increased to a maximum of 640 ppbv during the period of August 1, 1995 through December 27, 1999. This increase generally corresponds to the opening of the passive injection wells after July 29, 1995, suggesting that the use of the passive injection wells enhanced the system's performance.

Ft. Griffey occupies approximately 86,000 acres along the northern bank of the Ohio River, approximately 12 miles from Cincinnati, Ohio. Ft. Griffey began operating in 1917 and currently serves as a military reservation. Ft. Griffey is divided by I-5 into North Ft. Griffey and the Main Post.

Landfill 5 (LF5) is located on North Ft. Griffey near Reese Lake and Reese Springs, which is the primary drinking water supply for the fort. The 52 acre landfill is divided into three cells - South, Northeast, and Northwest - and is located adjacent to a gravel pit (Figure 1).

From the early 1950s to the late 1960s, LF5 was reportedly used for the disposal of refuse, including domestic and light industrial solid waste and construction debris, and for the disposal of liquid waste in unlined cells. In addition, LF5 was reportedly used as a gravel quarry in the 1940s and for equipment storage and maintenance. After disposal activities ceased, the landfill was covered with native materials such as sand, gravel and soil; the landfill is currently covered with trees and grass.

PREVIOUS INVESTIGATIONS

According to the 1993 remedial investigation (RI), there were no reports of hazardous waste disposal in LF5. However, historical aerial photographs show two suspected liquid waste disposal pits located in Northeast and South LF5 and evidence of equipment maintenance activities near Northeast LF5 . Tetrachloroethene (PCE) and trichloroethene (TCE) are suspected of having been used in degreasing and equipment maintenance operations at Ft. Griffey; leaks and spills of solvents from maintenance operations on or near LF5 and disposal of solvents in unlined pits are the suspected sources of contamination.

In 1988, a limited site investigation of LF5 was conducted by Larkin Midwest Laboratory. The investigation indicated that the shallow groundwater beneath the landfill was contaminated with chlorinated hydrocarbons, aromatic hydrocarbons, and manganese (Mn). While the data were not provided in the available references, TCE was reported to have been found at concentrations ranging from 1 to 32 micrograms per liter (µg/L).

In 1991, Remediation Enhanced Developments, Inc. (RED) conducted several pre-RI activities under contract with the U.S. Army Corps of Engineers (USACE) Louisville District including a test pit investigation, a passive soil gas survey, and a preliminary ecological assessment. According to RED, the results of these activities indicated that TCE and PCE were widely distributed in the area of LF5.

The RI, completed in 1993 by RED, again under contract with USACE Louisville District, included a more extensive landfill and soil gas survey and a groundwater investigation. The RI confirmed the presence of chlorinated hydrocarbons and aromatic hydrocarbons contamination at LF5. Elevated levels of TCE, PCE, and dichloroethene (DCE) were detected in the soil. TCE, vinyl chloride (VC) and benzene, toluene, ethylbenzene, and xylene (BTEX) contamination was detected in the groundwater. Elevated levels of Mn were also detected in the groundwater along the western borders of South and Northwest LF5. However, the RI attributes these elevated levels to the dissolution of Mn from geologic materials in the area of LF5.

Low levels of BTEX were detected in the lower aquifer (<0.5 µg/L to 5.8 µg/L). However, TCE, DCE, VC, and PCE, while detected in the upper aquifer, were not detected in the lower aquifer.

Mn and iron were detected in both the upper and lower aquifers. The RI determined that the elevated levels of Mn were caused by dissolution of manganese from geologic material.

Results of groundwater quality indicator parameters measured during the RI, including increased specific conductance, dissolved metals and biochemical oxygen demand, indicated that low levels of metals and inorganic compounds were leaching from the landfill into the upper aquifer. However, the parameters were reported to rarely exceed five times their background levels. There was no evidence of leaching to the lower aquifer.

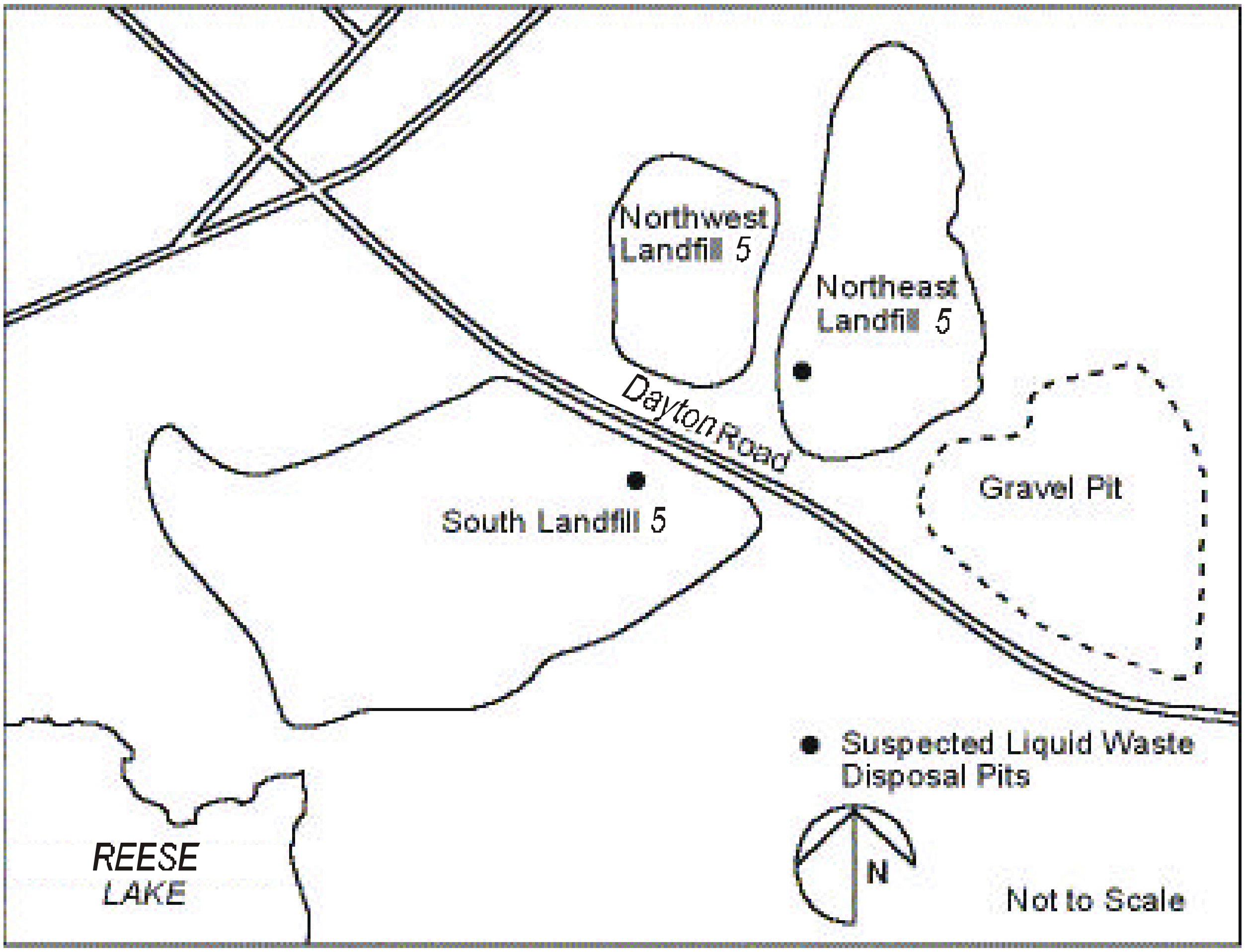

FIGURE 1
LANDFILL 5 – LOCATION OF CELLS

Based on the findings of the RI, the U.S. Environmental Protection Agency (USEPA), Region V, the U.S. Department of Defense (DoD), the Ohio Environmental Protection Agency (OEPA), and the USACE Louisville District negotiated a cleanup strategy and entered into a Federal facility agreement under Section 120 of CERCLA to address the contamination at LF5. These parties agreed to address LF5 as a single operable unit (OU) and commissioned a feasibility study (FS) in March 1993.

REMEDY SELECTION

In a record of decision (ROD) signed in October 1993, the remedy selected for LF5 included:

- Treatment of contaminated soils in areas that were suspected sources of groundwater contamination (soil hot spots) using soil vapor extraction (SVE);
- Treatment of contaminated groundwater using air sparging (AS);
- Monitoring of the upper aquifer to determine the effectiveness of the selected remedy; and,
- Maintenance of institutional controls, including access restrictions.

The groundwater AS system was to operate in conjunction with the SVE system.

The ROD also required that Mn be monitored in the groundwater in the localized areas where elevated levels were detected during the RI. The ROD specified that, if the results of the monitoring indicated that levels were not declining, then the need for remediation was to be reevaluated.

Including limited groundwater extraction and treatment in addition to AS/SVE was considered as an alternative remedy. However, AS/SVE was determined to be more cost effective than AS/SVE plus groundwater extraction and treatment while still being protective of human health and the environment.

The ROD specified four objectives for the remedy:

- To prevent exposure to contaminated groundwater;
- To restore the contaminated groundwater to its beneficial use (drinking water);
- To minimize movement of contaminants from soil to groundwater; and,
- To prevent exposure to the contents of the landfill.

No soil cleanup levels were identified. The cleanup levels established for groundwater in the upper aquifer beneath the site were:

- TCE - 5 µg/L - the Federal Safe Drinking Water Act maximum contaminant level (MCL);
- VC - 1 µg/L - the Ohio State Model Toxics Control Act Method B.

Monitoring of Mn was required along the western border of South and Northwest LF5 to determine any changes in concentration.

The remedial design (RD) for the AS/SVE system was completed in nine months and approved by USEPA October 5, 1994, for implementation of the remedial action.

The AS/SVE system was constructed between October 19 and December 29, 1994. Details of the system's construction are discussed below. Appendix A presents matrix characteristics and operating parameters.

PILOT SYSTEM

The pilot system used in this application consisted of one AS well, three SVE wells, ten vadose zone piezometer (VZP) wells, two groundwater monitoring wells, and three dissolved oxygen sensor (DOS) wells, as well as an impermeable plastic cover for the ground surface and well monitoring equipment. The AS and SVE wells were located near monitoring well LF5-MW8A, from which groundwater samples with the highest recorded TCE concentrations in the project area had been collected.

The AS well was used to inject clean air into the aquifer, using an above-ground blower, to strip volatile contaminants from the aquifer into the soil in the subsurface at the site. Dissolved oxygen (DO) concentrations in the aquifer were measured during AS using DOS wells. The DO results were used to estimate the radius of influence of the AS well during the pilot test. The SVE wells were used to extract volatile contaminants from the subsurface soil, and the VZP wells were used to measure the radius of influence of the SVE wells.

The impermeable plastic cover was used to enhance the radius of influence for the SVE wells by moving the air recharge boundary a greater distance from the SVE wells. The cover was constructed of a 20-millimeter (mil) thick layer of very low density polyethylene (VLDPE) and laid down over a cleared area. The cover had a radius of approximately 200 feet, and was covered with 4 to 6-inches of gravel to assure tight contact with the ground surface, and to allow for light vehicular traffic (pickup trucks) over the cover. All wells were drilled using a 4-inch inner diameter (ID) hollow stem auger.

Operation of the pilot system consisted of a SVE pilot test and a combined AS/SVE pilot test.

FULL-SCALE SYSTEM

The full-scale system used in this application consisted of five AS wells, six SVE wells, ten VZP wells, three groundwater monitoring wells, three DOS wells, four passive injection wells, and associated well-monitoring equipment. The passive injection wells were positioned where modeling results showed significant stagnation zones when two adjacent SVE wells were operated at the same time. The full-scale system also used the same impermeable plastic cover for the ground surface that was used in the pilot system. Two parallel systems of vapor-phase granular activated carbon (GAC) were used in the full-scale system.

Extracted vapors were first treated using a moisture (water/vapor) separator to remove entrained water, and then treated using activated carbon filter canisters (GAC), prior to discharge to the atmosphere.

The AS system consisted of an inlet particulate filter, compressor, moisture separator, and flow control valve.

The six SVE wells were piped to two parallel treatment trains, each consisting of a moisture separator, a blower, and two vapor-phase GAC canisters. These two parallel sets of equipment were operated to ensure that the system's performance would not be affected by a breakdown.

Well construction details for the full-scale system are provided below. Schematics of the SVE and AS systems, respectively, are shown in Figures 2 and 3.

Type of Well	No. of Wells	Depth of Well	Location of Well Screen	Screen Length (ft)	Screen Slot Openings (in)
AS	5	20 ft. below static water level (SWL); 50 ft below ground surface (BGS)	15 to 20 ft. below SWL	5	0.01
SVE	6	30 ft BGS	2 ft above seasonal high water level (SHWL) to 12 ft above SHWL	10	0.01
VZP	10	30 ft. BGS	2 ft. above SHWL to 12 ft. above SHWL	10	0.01
Groundwater monitoring	3	40 ft. BGS	1 ft. above SHWL to 7-8 ft. below SHWL	10	0.01
DOS	3	40 ft. BGS	1 ft. above SHWL to 7-8 ft. below SHWL	10	0.01
Passive injection	4	30 ft. BGS	2 ft. above SHWL to 12 ft. above SHWL	10	0.01

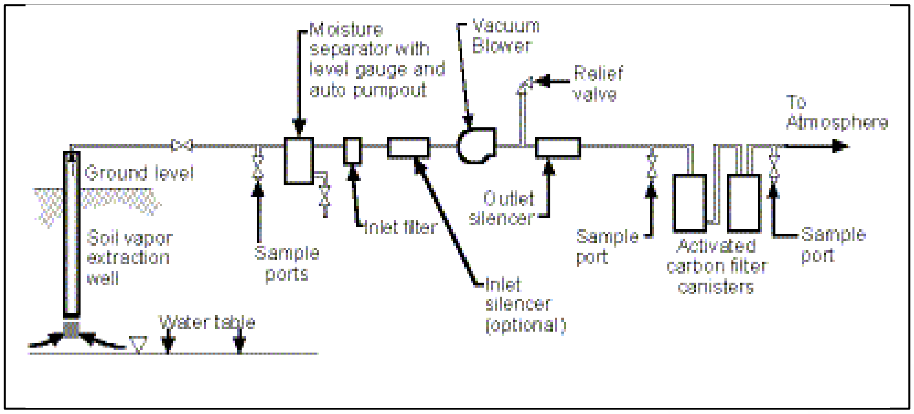

FIGURE 2
SOIL VAPOR EXTRACTION SCHEMATIC FOR LANDFILL 5

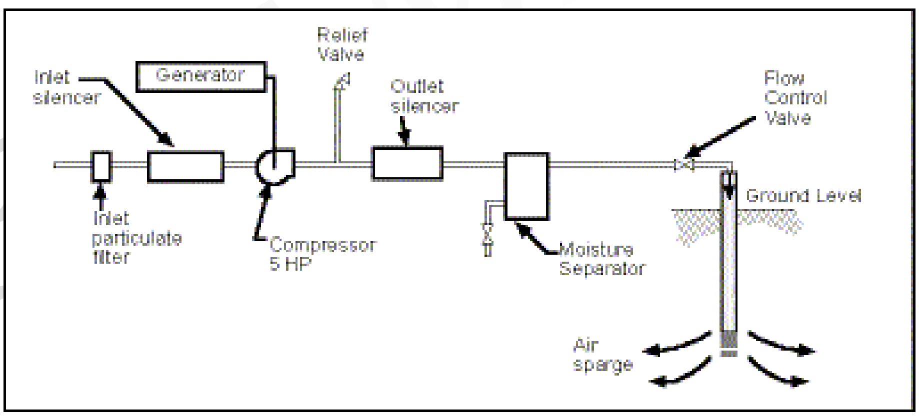

FIGURE 3
AIR SPARGING SCHEMATIC FOR LANDFILL 5

The following table includes the dates of the most significant events in the operation of the AS/SVE system at LF5.

Date	Activity
October 15, 1993	Record of decision signed
July 13, 1994	Remedial design submitted
October 5, 1994	Remedial design approved
October 19, 1994	Construction of the AS/SVE system began
December 29, 1994	Construction of the AS/SVE system completed
January 5-15, 1995	AS/SVE pilot test conducted at LF5
April 1, 1995	AS/SVE startup activities at LF5
July 29, 1995	Preliminary closeout report signed for site construction completion
September 4, 1995	Operating Properly and Successfully determination made
December 7, 1999	Data collection for Chemical Data Report #5 completed
December 27, 1999	USEPA, DoD, OEPA, and USACE representatives participated in the contract pre-final inspection and the Federal facilities agreement inspection, held simultaneously
Ongoing	AS/SVE full-scale operation

The overall performance of the AS/SVE system, as compared to the performance objectives, is discussed below.

PERFORMANCE OBJECTIVES

The ROD specified four objectives for the remedy:

- To prevent exposure to contaminated groundwater;
- To restore the contaminated groundwater to its beneficial use (drinking water);
- To minimize movement of contaminants from soil to groundwater; and,
- To prevent exposure to the contents of the landfill.

No soil cleanup levels were identified. The cleanup levels established for groundwater in the upper aquifer beneath the site were:

- TCE - 5 µg/L - the Federal Safe Drinking Water Act MCL
- VC - 1 µg/L - the Ohio State Model Toxics Control Act Method B

Monitoring of Mn was required along the western border of South and Northwest LF5 to determine any changes in concentration.

A site-specific air emission threshold limit of 2.5 parts per million volume (ppmv) TCE was calculated by USACE using Screen Model 3 and the Riverfront Air Pollution Control Agency (RAPCA) acceptable source impact levels. The air stream between the first and second carbon canisters is monitored every other week using a photoionization detector (PID). The PID breakthrough action level is 1.5 ppmv total VOCs. The breakthrough action level is used to determine when the first carbon bed needs to be removed from service.

To assess the overall performance of the system, performance monitoring is required throughout the operation of the system. The specific requirements are detailed in the compliance monitoring plan and include contaminant reduction monitoring to evaluate progress towards achieving the cleanup goals, contaminant migration monitoring to confirm that the plume is being contained, and contaminant treatment monitoring for air emissions.

TREATMENT PERFORMANCE DATA AND ASSESSMENT

The full-scale system operation began when the startup activities were completed on July 29, 1995. The full-scale system operation is currently ongoing. Performance data through December 7, 1999 were included in Chemical Data Report #5, which was the most recent document used in preparation of this report.

In general, the SVE system was operated between 0 and 1,290 standard cubic feet per minute (scfm) extracted, and the air sparging system was operated at between 0 and 210 scfm injected. The passive air injection wells initially remained closed from April 1, 1995 and July 29, 1995, after which they were opened. It was determined that the passive injection wells should remain open unless a detrimental effect could be demonstrated.

The concentration of TCE in the soil gas extracted by the SVE system generally decreased from 210 parts per billion by volume (ppbv) to 140 ppbv during the period of April 1, 1995 through July 27, 1995. The extracted soil gas concentration then increased to a maximum of 640 ppbv during the period of August 1, 1995 through December 27, 1999. This increase generally corresponds to the opening of the passive injection wells after July 29, 1995, suggesting that the use of the passive injection wells enhanced the system's performance.

Groundwater Sampling

Twenty-two rounds of groundwater sampling have been conducted (two before the remediation system was installed and four times per year for five years after the system's installation). The first round of sampling was performed during March 1994 and the last round for which data was available was performed in December 1999.

TCE was the only contaminant in groundwater consistently identified above the cleanup levels established for the site. In addition, monitoring for Mn was required.

The average TCE concentration in the contaminant reduction monitoring wells has decreased from 79 to 6.4 mg/L from March 1994 to December 1999, while the average TCE concentration in the migration monitoring wells has showed no consistent trend (average concentrations have ranged from 3.78 to 12.03 mg/L). TCE concentrations in both areas were still above the site cleanup level of 5 mg/L in December 1999.

The average total Mn concentration in the contaminant reduction monitoring wells has decreased from 11,000 mg/L in March 1994 to 8.0 mg/L in December 1999, while the average Mn concentration in the migration monitoring wells has generally decreased from 488.0 to 40.0 mg/L) during the same time period.

Vinyl chloride, the other contaminant with a cleanup level for the site, was only detected above method detection limits on one occasion (March 1997)and was never detected above site cleanup levels.

Air Emissions Sampling

Based upon the system performance testing of the AS/SVE system, the air effluent from the system was determined to be several magnitudes below the RAPCA emission action levels. Therefore, because the RAPCA emission action levels would not be exceeded during the SVE system's operation, additional air sampling was not required.

PERFORMANCE DATA QUALITY

According to the technical memorandum on the results of the pilot study, the required QA/QC samples were collected. Field duplicates, field blanks, rinsate blanks, and travel blanks were required in the final management plan for the LF5 pilot study for QA/QC of the field study sampling program. Method blanks, reagent blanks, matrix spike samples, matrix spike duplicates, duplicates, and laboratory control samples were required for laboratory QA/QC. No exceptions to the QA/QC procedures were noted in any of the field sampling or laboratory reports.

With the exception of DO data from the second quarter of 1996, no significant data quality problems were identified. This DO data were determined to be unacceptable as a result of significant fluctuations measured from the sensors. The problem did not reoccur in any of the subsequent sampling data.

INSPECTIONS

The pre-final and the Federal facilities agreement inspections of the AS/SVE system construction were conducted simultaneously on December 27, 1999, in the presence of USEPA, DoD, OEPA, and USACE representatives.

Observations, inspections, and testing during operation of the AS/SVE treatment system found no significant operational problems affecting the performance of the remedial action.

CERTIFICATIONS

On September 4, 1995, the AS/SVE system was certified as Operating Properly and Successfully. This determination was required under the Federal facilities agreement.

HEALTH AND SAFETY

No health and safety problems were encountered during construction or operation. Modified Level D personal protective equipment (PPE) was required for all site personnel who entered the site. The equipment included coveralls, safety boots, and nitrile gloves.

The quarterly groundwater monitoring program began in March 1994. TCE concentrations in both areas were still above the site cleanup level of 5 mg/L in December 1999. The average total Mn concentration in the contaminant reduction monitoring wells has decreased from 11,000 mg/L in March 1994 to 8.0 mg/L in December 1999, while the average Mn concentration in the migration monitoring wells has generally decreased from 488.0 to 40.0 mg/L) during the same time period. Vinyl chloride, the other contaminant with a cleanup level for the site, was only detected above method detection limits on one occasion and was never detected above site cleanup levels.

It is anticipated, based on the effectiveness of the AS/SVE system, that the site cleanup level of 5 mg/L for TCE concentrations will be attained for all monitoring wells in approximately 2002 (Year 7). As specified in the ROD, after this objective has been achieved the AS/SVE system will continue to operate for an additional 3 months to ensure that the site has been remediated.

As specified in the ROD, the quarterly monitoring of groundwater will continue through 2009 (Year 15) to confirm that groundwater will not be adversely impacted by the land treatment activities.

The table below summarizes total actual project costs for the Landfill 5 operable unit RA. Appendix B provides a breakdown of these costs incurred to-date as well as a breakdown of projected costs.

Cost Item	Adjusted ROD Estimate	Actual Cost[1]	Difference
Capital Costs, Year 0 (1994)	$688,013	$729,294	+ 6 %
O&M Costs, Years 1-5 (1995-1999)	$993,522	1,102,810	+ 11 %
Periodic Costs, Year 5 (1999)	$20,000	20,000	0 %
Total Costs, Years 0-5	$1,701,535	$1,852,104	+ 9 %

1 Costs are based on the respective years that the costs were incurred (e.g., Year 1 ended in 1995 and Year 5 ended in 1999; therefore, these costs are reported in 1995, 1996, 1997, 1998, and 1999 dollars, respectively). The ROD estimates were adjusted from 1993 dollars to the appropriate year's dollar using ENR building cost index factors.

Total projected costs for Years 6 through 15 are $2,111,483 with O&M costs of $2,057,839 and periodic costs of $53,644 using 2000 as the base year of the estimate. This compares to an adjusted ROD estimate cost of $2,006,910 for O&M (+2.5%) and $50,000 for periodic costs (+1%) for this period.

PERFORMANCE

During the operation of the treatment system in SVE-only mode, TCE concentrations were reduced from initial concentrations of 235 ppb to 110 ppb. The addition of AS to the system reduced TCE concentrations in the soil gas from initial concentrations of 110 ppb to 56 ppb.

The AS/SVE system reduced TCE concentrations in groundwater. At the three wells located near suspected hot spots of contamination, TCE concentrations were reduced from 310 ppb to 170 ppb (DOS-1), from 220 ppb to 170 ppb (DOS-2), and from 140 ppb to 23 ppb (MW8A). However, the concentrations remained above the cleanup goal of 5 ppb for TCE.

The results of Mn sampling before and after sparging indicated that Mn levels decreased in six of the eleven wells samples, but increased in five of the wells.

The following observations were made in a technical memorandum summarizing the system's operation.

- With respect to optimal air extraction rate, an extraction rate of 110 scfm is likely to capture all volatilized contaminants within about 200 feet of each extraction well.
- The radius of influence of an air injection well is about 20-30 feet.
- A pressure of approximately 8 psi was required to overcome resistance in the injection well. However, at injection pressures above 8 psi, air bubbles would be more likely to occur. At 8 psi, the air injection rate into the aquifer was about 45 scfm. The 45 scfm (8 psi pressure) was determined to be the optimal flow rate, reflecting site and conditions of injections 12 feet below static water level. The vendor noted that changes in depth of the injection well will affect the injection pressure and radius of influence.
- The major problem encountered during the pilot test was that the SVE vacuum pump did not produce a vacuum sufficient to be detected by the automated sensors. Because of schedule constraints, a larger blower could not be obtained. However, according to the vendor, adequate data was obtained from the pilot test to design the full-scale system.

While overall TCE concentrations decreased in the groundwater, there were several instances when TCE concentrations increased during operation. These increases may be attributed to the new source material (from contaminated soil) infiltrating into the groundwater.

COST

The total cost for the pilot study of the AS/SVE system at LF5 was $241,000. This amount is not included in the amounts shown in Table 8-1.

Differences between the actual costs and the adjusted ROD estimates are largely attributable to the installation of passive injections wells, a SVE system capable of sustaining a 600 scfm average volumetric airflow rate, and additional groundwater monitoring wells, and the increased groundwater sampling costs associated with the additional wells. However, as shown in

Table 8-1, the actual costs that have been incurred to this point were just 9% above the corresponding, adjusted ROD estimate.

Subsequent to original negotiations, the contaminant concentrations in system air emissions were determined to be significantly below the allowable air emission standards, and RAPCA agreed to allow USACE to eliminate the need to change the carbon units from the system and to reduce air compliance monitoring requirements. USACE is planning to reallocate money from any savings on air compliance monitoring to increase the number of system performance air tests.

Because the system operation is ongoing, the total costs to operate the system are not known at this time. Actual costs to date are shown in Table B-1, and projected additional cost to complete is shown in Table B-2.

SYSTEM OPERATION

The emphasis of vapor data collection in the future should shift to the individual extraction wells rather than the combined extracted flow. In the fifth quarter of the full-scale operation, quarterly vapor sampling from the individual wells was initiated.

Based on the testing of the untreated and the treated condensate removed by the remediation system, the potential life of the aqueous-phase carbon units was estimated to be in excess of ten million gallons.

An SVE system flow rate of less than the design maximum flow rate may be more efficient for TCE removal than continuous operation at the maximum flow rate. The vendor recommended that the system be evaluated at moderate SVE system flow rates during the ongoing optimization of the system.

The data supports the remedial investigation findings that numerous TCE hot spots exist at the site, and that the presence of TCE (and/or its degradation products) at one location may or may not be related to its presence at other locations at the site.

Studying the natural degradation of the leachate at the site may provide a more widespread picture of the fate of contamination at the site than focusing on the natural attenuation of chlorinated hydrocarbons alone.

Although the impact of the AS system on the degradation of TCE at the site had not been conclusively determined, it was recommended that the AS system continued to be operated until an impact/ benefit analysis for the system is completed.

Because one of the contaminant reduction monitoring wells upgradient of the remediation system had maintained an elevated concentration of TCE, a TCE hot spot may be located upgradient of this location beyond the influence of the remediation system. An additional AS/SVE well pair could be added to this area to increase the reach of the remediation system.

The concentrations of contaminants downgradient from the treatment system may remain above the cleanup levels for the site, even if contaminant concentrations are reduced to below cleanup levels in the treatment system area.

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Phone Number: (555) 555-4444

Contract Number: 9999-8888-7777FG

Work Assignment Number:

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Email: thomas@epa.gov

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2. Remediation Enhanced Developments, Inc. 1993. Final Feasibility Study Report, Landfill 5 and Solvent Refined Coal Pilot Plant, Ft. Griffey, Ohio. Prepared for USACE, Louisville District. May.

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4. Remediation Enhanced Developments, Inc. 1995. Preliminary Closeout Report, Landfill 5 Remediation, Ft. Griffey, Ohio. For USACE Contract No. DACA99-99-Z-9999-99. June 1.

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8. Remediation Enhanced Developments, Inc. 1998. Chemical Data Report #4, Landfill 5 Remediation, Ft. Griffey, Ohio. For USACE Contract No. DACA99-99-Z-9999-99. December 31.

9. Remediation Enhanced Developments, Inc. 1999. Chemical Data Report #5, Landfill 5 Remediation, Ft. Griffey, Ohio. For USACE Contract No. DACA99-99-Z-9999-99 December 31..

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13. U.S. EPA. 1995. Letter regarding Signing of Preliminary Closeout Report, Ft. Griffey Landfill 5 Remediation. July 29.

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16. USACE, Louisville District. 1994. Government Cost Estimate for Cover Air Sparging/Soil Vapor Extraction Pilot Test, Landfill 5, Ft. Griffey, Ohio, Department of the Army. August.

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18. USACE, Louisville District. 1999. Inspection Results: Pre-Final and Federal Facilities Agreement. December 30.

19. USACE, Louisville District. 1997. Letter from Sean Casey, P.E. to Jack McKeon, Riverfront Air Pollution Control Agency. December 5.

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21. USACE, Louisville District. Undated. Design Analysis, Ft. Griffey, LF5, AS/SVE Final Remedial Design.

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The following table details matrix characteristics that may affect cost and performance of the AS/SVE system.

MATRIX CHARACTERISTICS

Parameter	Site Condition
Soil Classification	Sandy gravel to sandy silty gravel (see Table A-3)
Particle Size Distribution	Stratigraphic units range from well sorted to unsorted (see Table A-3)
Moisture Content	9 - 12 %
Air Permeability	1.6 x 10^{-7} cm^2 (calculated using field measurements and steady state equation)
Hydraulic conductivity	232 darcies (sieve analysis) 370 darcies (computer modeling)
Effective Porosity	30%
Total Organic Carbon	580 -17,000 ppb (as measured during the pilot study)

The following table details operating parameters of the AS/SVE system.

OPERATING PARAMETERS

Operating Parameter	Value and Units
Soil Vapor Extraction System	
Air flow rate	440 - 1290 scfm
Operating vacuum	5-inches mercury vacuum at blower inlet
Operating time	Continuous
Temperature	85 – 155°F
Air Sparging System	
Air flow rate	60 - 210 scfm
Operating pressure	7 pounds per square inch (psi) (design value)
Operating time	Cyclical

The following tables present a summary of actual (Years 0-5) and projected (Years 6-15) costs and calculation of technology-specific unit costs for soil vapor extraction and air sparging. HCAS data entry sheets are attached to this appendix.

ACTUAL COSTS (1 of 2)

Site:	Landfill 5	**Description:**	The selected treatment technology consists of air sparging in combination with soil vapor extraction in the source area. Capital costs were incurred in Year 0 (1994). Actual O&M costs were incurred in Years 1 (1995) through 5 (1999). Projected O&M costs are assumed for Years 6 (2000) through 15 (2009). Periodic costs are incurred in Years 5, 10, and 15.
Location:	Ft. Griffey, Ohio		
Phase:	Interim RA Report		
Base Year:	1994, 1995-1999, 2000		
Date:	April 9, 2001		

RA CAPITAL COSTS (Year 0):

DESCRIPTION	QUANTITY	UNIT	UNIT COST	COST	NOTES
331XX HTRW Remedial Action					
.01 Mobilization and Preparatory Work					
.01 Mob Construction Equipment & Facilities	1	EA	$2,472	$2,472	
.03 Submittals/Implementation Plans	1	EA	$13.504	$13.504	QAPP, SSHP, etc.
.05 Construct Temporary Utilities	1	EA	$1,274	$1,274	
SUBTOTAL				$17.250	
.02 Monitoring, Sampling, Testing, and Analysis					
.04 Monitoring Wells	7	EA	$2.965	$20.757	Saturated zone screen interval
.11 Geotechnical Testing	10	EA	$230	$2,300	Screen interval soil samples
.90 Vadose Zone Piezometers	10	EA	$1.577	$15.771	Installed to water table depth
.91 Dissolved Oxygen Sensor Wells	3	EA	$2.965	$8.896	Saturated zone screen interval
SUBTOTAL				$47,724	
.03 Sitework					
.02 Clearing and Grubbing	3.0	AC	$1.161	$3.482	Work area
.03 Earthwork - Stockpile Topsoil	2.420	CY	$0.51	$1.234	Strip 0.5'
SUBTOTAL				$4,717	
.13 Physical Treatment					
.32 Air Sparging (37,400 MGA)					
.90 AS Injection Wells	5	EA	$4.645	$23.225	Well depth = midpoint of aquifer
.91 AS Blower	1	EA	$5,712	$5,712	
.92 AS Piping	100	LF	$5.03	$503	Pipe, valves, fittings, etc.
.93 Electrical Hookup	1	EA	$4.949	$4.949	
.94 Startup and Testing	1	EA	$5.468	$5.468	
SUBTOTAL				$39.857	
.13 Physical Treatment					
.23 Soil Vapor Extraction (27,800 CY)					
.90 Mobilize SVE System	1	EA	$1.534	$1.534	Mobile unit
.91 Impermeable Surface Cover	125.500	SF	$0.84	$105.420	Low density polyethylene liner
.92 SVE Extraction Wells	6	EA	$3.725	$22.350	Installed to water table depth
.93 SVE Passive Injection Wells	4	EA	$2.286	$9.144	Installed to water table depth
.94 SVE System	1	EA	$93.510	$93.510	Mobile unit (600 scfm)
.95 GAC System	2	EA	$102,596	$205,192	
.96 SVE Piping	400	LF	$8.66	$3.464	Pipe, valves, fittings, etc.
.97 Electrical Hookup	1	EA	$4.949	$4.949	
.98 Startup and Testing	1	EA	$5,468	$5.468	
SUBTOTAL				$451.031	
.19 Disposal (Commercial)					
.20 Container Handling	30	Each	$60	$1.800	Transport/disposal of drums - SWLF
.90 Wastewater Discharge/Testing	200	Gallon	$1.25	$250	POTW fee - development water
SUBTOTAL				$2.050	
.20 Site Restoration					
.01 Earthwork - Spread/Compact Topsoil	2.420	Cubic Yard	$1.86	$4.501	Replace topsoil
.04 Revegetation and Planting	3.0	Acre	$1,427	$4,281	Seeding/mulch/fertilizer - work area
SUBTOTAL				$8.783	
.21 Demobilization					
.02 Removal of Temporary Utilities	1	EA	$546	$546	
.04 Demob Construction Equipment & Facilities	1	EA	$1,059	$1,059	
.06 Submittals	1	EA	$5.788	$5.788	Post-const. reports
SUBTOTAL				$7.393	
SUBTOTAL				$578.805	
Project Management				34.728	
Remedial Design				69.457	
Construction Management				46.304	
TOTAL RA CAPITAL COST (Year 0)				**$729,294**	1994

ACTUAL COSTS (2 of 2)

O&M COSTS (Years 1-5):

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
342XX HTRW O&M					
.02 Monitoring, Sampling, Testing, and Analysis					
.90 Performance Monitoring - SVE Vapor	5	YR	$22,149	$110,745	1 sample/month * 6 extraction wells
.91 Performance Monitoring - SVE Emissions	5	YR	$3,692	$18,460	1 sample/month - SVE exhaust
.92 Site Groundwater Sampling (Quarterly)	5	YR	$36,399	$181,995	Sample 8 wells/event VOCs, metals
.93 Site Groundwater Lab Analysis	5	YR	$21,839	$109,195	Analysis for above
SUBTOTAL				$420,395	
.13 Physical Treatment					
.32 Air Sparging (37,400 MGA)					
.90 Operations Labor	5	YR	$29,376	$146,880	54 manhours per month
.91 Maintenance Labor	5	YR	$3,456	$17,280	6 manhours per month
.92 Equipment Repair	1	EA	$1,000	$1,000	
.93 Utilities	5	YR	$9,254	$46,268	Electricity + fuel
SUBTOTAL				$211,428	
.13 Physical Treatment					
.23 Soil Vapor Extraction (27,800 CY)					
.90 Operations Labor	5	YR	$44,064	$220,320	82 manhours per month
.91 Maintenance Labor	5	YR	$5,184	$25,920	10 manhours per month
.92 Equipment Repair	1	EA	$1,500	$1,500	
.93 Utilities	5	YR	$13,880	$69,402	Electricity + fuel
SUBTOTAL				$317,142	
.18 Disposal (Other than Commercial)					
.90 Wastewater Discharge/Testing	8,000	GA	$1.25	$10,000	Purge & knockout water
SUBTOTAL				$958,965	
Project Management				47,948	
Technical Support				95,897	
TOTAL O&M COST (Years 1-5)				**$1,102,810**	1995-1999

PERIODIC COSTS (Year 5):

DESCRIPTION	YEAR	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Five Year Review Report	5	1	Each	$12,000	$12,000	1 report at end of Year 5
Interim RA Report	5	1	Each	$8,000	$8,000	
TOTAL PERIODIC COST (Year 5)					**$20,000**	1999

TOTAL COST (Years 0-5)	**$1,852,104**

PROJECTED COSTS

Site:	Landfill 5	**Description:**	The selected treatment technology consists of air sparging in combination with soil vapor extraction in the source area. Capital costs were incurred in Year 0 (1994). Actual O&M costs were incurred in Years 1 (1995) through 5 (1999). Projected O&M costs are assumed for Years 6 (2000) through 15 (2009). Periodic costs are incurred in Years 5, 10, and 15.
Location:	Ft. Griffey, Ohio		
Phase:	Interim RA Report		
Base Year:	1994, 1995-1999, 2000		
Date:	March 30, 2001		

O&M COSTS (Years 6-15):

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
342XX HTRW O&M					
.02 Monitoring, Sampling, Testing, and Analysis					
.90 Performance Monitoring - SVE Vapor	10	YR	$22.149	$221.490	1 sample/month * 6 extraction wells
.91 Performance Monitoring - SVE Emissions	10	YR	$3.692	$36.920	1 sample/month - SVE exhaust
.92 Site Groundwater Sampling (Quarterly)	10	YR	$18,200	$182,000	Sample 8 wells/event VOCs, metals
.93 Site Groundwater Lab Analysis	10	YR	$10.920	$109.200	Analysis for above
SUBTOTAL				$549.610	
.13 Physical Treatment					
.32 Air Sparging					
.05 Utilities	10	YR	$9.254	$92.536	Electricity + fuel
.09 Operations Labor	10	YR	$29.376	$293.760	54 manhours per month
.10 Maintenance Labor	10	YR	$3.456	$34.560	6 manhours per month
.90 Equipment Repair	1	EA	$2.000	$2.000	
SUBTOTAL				$422,856	
.13 Physical Treatment					
.23 Soil Vapor Extraction					
.05 Utilities	10	YR	$13.880	$138.804	Electricity + fuel
.09 Operations Labor	10	YR	$44,064	$440,640	82 manhours per month
.10 Maintenance Labor	10	YR	$5.184	$51.840	10 manhours per month
.90 Equipment Repair	1	EA	$3.000	$3.000	
SUBTOTAL				$634.284	
.18 Disposal (Other than Commercial)					
.90 Wastewater Discharge/Testing	16.000	GA	$1.25	$20.000	Purge & knockout water
SUBTOTAL				$1.626.750	
Contingency	10%			162.675	
SUBTOTAL				$1.789.425	
Project Management	5%			89.471	
Technical Support	10%			178.943	
TOTAL O&M COST (Years 6-15)				**$2.057.839**	2000

PERIODIC COSTS (Years 10, 15):

DESCRIPTION	YEAR	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Five Year Review Report	10	1	Each	$12.000	$12.000	1 report at end of Year 10
Demob SVE System 342XX.13.23.99	15	1	Lump Sum	$14,250	$14,250	Remove equipment and piping
Demob AS System 342XX.13.32.99	15	1	Lump Sum	$7.125	$7.125	Remove equipment and piping
Well Abandon 342XX.02.04.20	15	28	Each	$350	$9.800	
Contingency (% of Sum)		15%			4.676	% of construction activities
Project Mgt. (% of Sum + Cont.)		5%			1.793	% of construction + contingency
Final RA Report	15	1	Each	$4.000	$4.000	
SUBTOTAL					$41.644	
TOTAL PERIODIC COST (Years 10, 15)					**$53,644**	2000

TOTAL PROJECTED COST (Years 6-15)	**$2,111,483**

SOIL VAPOR EXTRACTION TECHNOLOGY-SPECIFIC UNIT COST CALCULATION	
ACTUAL CAPITAL COSTS (Year 0):	
Monitoring, Sampling, Testing, and Analysis[1]	$15,771
Physical Treatment[2]	$451,031
Disposal (Other than Commercial)[3]	$800
SUBTOTAL	$467,602
ACTUAL O&M COSTS (Years 1-5):	
Monitoring, Sampling, Testing, and Analysis[4]	$129,205
Physical Treatment[2]	$317,142
SUBTOTAL	$446,347
PROJECTED O&M COSTS (Years 6-15):	
Monitoring, Sampling, Testing, and Analysis[4]	$258,410
Physical Treatment[2]	$634,284
SUBTOTAL	$892,694
PROJECTED PERIODIC COSTS (Years 10, 15):	
Demobilize SVE System[2]	$14,250
Well Abandonment[2]	$7,000
SUBTOTAL	$21,250
TOTAL TECHNOLOGY-SPECIFIC COST	$1,827,893
Soil to be Treated (Cubic Yards)[5]	27,800
TECHNOLOGY-SPECIFIC UNIT COST (Per Cubic Yard)	**$65.75**

[1] SVE vadose zone piezometers
[2] SVE system only
[3] Disposal of SVE piezometer soil cuttings
[4] SVE performance monitoring
[5] Within zone of influence

AIR SPARGING TECHNOLOGY-SPECIFIC UNIT COST CALCULATION	
ACTUAL CAPITAL COSTS (Year 0):	
Monitoring, Sampling, Testing, and Analysis[1]	$19,172
Physical Treatment[2]	$39,857
Disposal (Other than Commercial)[3]	$1,150
SUBTOTAL	$60,179
ACTUAL O&M COSTS (Years 1-5):	
Physical Treatment[2]	$211,428
PROJECTED O&M COSTS (Years 6-15):	
Physical Treatment[2]	$422,856
PROJECTED PERIODIC COSTS (Years 10, 15):	
Demobilize AS System[2]	$7,125
Well Abandonment[2]	$2,800
TOTAL	$9,925
TOTAL TECHNOLOGY-SPECIFIC COST	$704,388
Groundwater to be Treated (MGA)[4]	37,400
TECHNOLOGY-SPECIFIC UNIT COST (Per 1,000 Gal)	**$18.83**

[1] AS monitoring wells (3), DOS wells (3), geotechnical testing
[2] AS system only
[3] Disposal of AS wells soil cuttings and development water
[4] Within treatment zone - includes flushed volume (MGA = 1,000 gallons)

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 1)

Project Information

Project Name	Landfill 5 Operable Unit
Project Number	
Project Phase (Select one)	
Studies and Design	
Remedial Action	✓
Operations and Maintenance	

Project Note (Describe the project)

Soil Vapor Extraction treatment technology was utilized to remediate 27,800 cy (estimated) of contaminated soil in conjunction with Air Sparging treatment technology, which was utilized to remediate 37,400,000 gallons (estimated) of contaminated groundwater.

Contract Information

Contract Number	DACA27-94-C-0300
Managing Organization	U.S. Army Corps of Engineers
Organization Name	Louisville District
Site Owner	U.S. Army
Other ID Number	
Prime Contractor	Remediation Enhanced Developments, Inc. (RED)
Contract Type (Select one)	
Cost + Award Fee	
Cost + Base + Award Fee	
Cost + Fixed Fee	✓
Cost + Incentive Award	
Fixed Price	
Not Availiable	
Other	
Procurement Type (Select one)	
Two Step Sealed Bid	
Sealed Bid (IFB)	
Competitive Negotiation (RFP)	✓
Sole Source (SSC)	
Other	

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 2)

Site Information

State/Country	Ohio/USA
Installation	Ft. Griffey
Site Name	Landfill 5
Site Number	
EPA Region	V

Current Use (Select one)

Installation Operation	✓
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	
Administrative Office	
Commercial	
Other	
Unknown	

Future Use (Select one)

Installation Operation	✓
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	
Administrative Office	
Commercial	
Other	
Unknown	

Point of Contact

	Data Entry Person	POC#2	POC#3
Title/Role	Contractor Estimator		
Organization	RED, Inc.		
Name	Joe Morgan		
Address	535 Red Way		
City, State	Cincinnati, OH		
Zip	99992		
Telephone	555-111-2222		
Fax	555-111-2223		
Email	jmorgan@red.com		

Enter up to 3 POC's.

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 3)

Profile - General Characteristics

Regulatory Class		Public Concern	
CERCLA	✓	Low	✓
RCRA		High	
Other		Historical/Archoelegical	
Unknown		Yes	
National Priority List		No	✓
Yes	✓	Innovative Technology	
No		Yes	
Wetland		No	✓
Yes		Size of Exclusion Zone (Acres)	
No	✓	Size of Area (Acres)	
Flood Plain			
Yes			
No	✓		

Profile - Contaminants/Technical Approach

Site Type	**Media**	**Contaminant**	**Technical Approach**
AG Storage Tanks	Air	Nonhal VOC's	CWM/OEW Remvl
UG Storage Tanks	Equipment/Mach	Halogenated VOC's	Surf Water Control
Drums/Cont <250 GA	Groundwater	Nonhal Semi VOC's	Grnd Water Control
Unauth Disposl Area	Liquid	Halogen Semi VOC's	Air/Gas Control
Facil/Bldgs	Surface Water	Fuels	Solids Contain
Fire Train/Open Burn	Sediment	Inorganics	Liq/Sed/Sludge Cntrl
Firing Rnge/Open Det	Sludge	Low Lev Rad Waste	Drums/Tanks Remvl
Pit/Trench	Soil	High Lev Rad Waste	Biological Treatment
Surf Impnd/Lagoons	Solid/Debris	Low Rad Mixed Wst	Chemical Treatment
Lakes/Ponds/Swamp	Struct Bldg Matls	TRU Waste	Physical Treatment
Landfill	Other	CWM/OEW	Thermal Treatment
Ocean		Asbestos	Stab/Fix/Encap
Rivers/Streams		Unknown	Decon & Decommish
Spill/Emerg Resp		Other	Disposal (Not Comm)
Waste Pile			Disposal Commercial
Other			Other

Pick as many Profile combinations as necessary:

Landfill	Soil	Fuels	Physical Treatment
Landfill	Groundwater	Fuels	Physical Treatment

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 4)

Cost

Start Date	10/19/1994
End Date	9/4/1995
Number of Mods	0
Reasons for Mods (Select those applicable)	
Administrative	
Changes for Time or Cost	
Changes Requested by Government Authority	
Design Deficiency	
Differing Site Conditions	
Funding Level Change	
New Federal Regulation	
Other Changes	
Suspension or Termination of Work	
Value Engineering Change	
Variations in Estimated Quantities	
Variations Not Readily Identifiable During Design	
Cost	
Award Amount	$2,900,000
Actual Amount	$3,195,695
Cost Variance	+10%

Cost Breakdown

See next sheets.

The HCAS Cost Breakdown is structured in accordance with the February 1996 "HTRW Remedial Action Work Breakdown Structure (RA WBS)" and "HTRW O&M Work Breakdown Structure (O&M WBS)".

The next sheets show the RA WBS and O&M WBS to the Third Level as required for the HCAS cost report portion of the "RA Report".

The costs reported shall be "Burdened Costs", meaning that contractor markups, general requirements, overhead, and profit shall be included in the costs.

The complete RA WBS and O&M WBS to the Fourth Level is at:
http://www.FRTR.gov/cost/ec2/wbs1.html

The HCAS 3.1 software can be downloaded from:
http://www.FRTR.gov/cost/ec2/index.html

WBS Number			DESCRIPTION	QTY	UOM	UNIT COST	COST $
33XXX			**HTRW CONSTRUCTION ACTIVITIES**				
331XX			**HTRW REMEDIAL ACTION (Capital and Operating)**				
	01		**MOBILIZATION AND PREPARATORY WORK**				
	01	01	Mobilization of Construction Equipment and Facilities	1	EA	2,472	2,472
	01	02	Mobilization of Personnel		EA		
	01	03	Submittals/Implementation Plans	1	EA	13,504	13,504
	01	04	Setup/Construct Temporary Facilities		EA		
	01	05	Construct Temporary Utilities	1	EA	1,274	1,274
	01	06	Temporary Relocations of Roads/Structures/Utilities		EA		
	01	07	Construction Plant Erection		EA		
	01	08	Institutional Controls		EA		
	01	09	Alternate Water Supply		EA		
	01	10	Population Relocation		EA		
	01	9X	Other (Use Numbers 90-99)				
	02		**MONITORING, SAMPLING, TESTING, AND ANALYSIS**				
	02	01	Meteorological Monitoring		EA		
	02	02	Radiation Monitoring		EA		
	02	03	Air Monitoring and Sampling		EA		
	02	04	Monitoring Wells	7	EA	2,965	20,755
	02	05	Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06	Sampling Soil and Sediment		EA		
	02	07	Sampling Asbestos		EA		
	02	08	Sampling Radioactive Contaminated Media		EA		
	02	09	Laboratory Chemical Analysis		EA		
	02	10	Radioactive Waste Analysis		EA		
	02	11	Geotechnical Testing	10	EA	230	2,300
	02	12	Geotechnical Instrumentation		EA		
	02	13	On-Site Laboratory Facilities		EA		
	02	14	Off-Site Laboratory Facilities		EA		
	02	9X	Other (Use Numbers 90-99)	1	LS	24,667	24,667
	03		**SITEWORK**				
	03	01	Demolition		SY		
	03	02	Clearing and Grubbing	3	ACR	1,161	3,482
	03	03	Earthwork	2,420	CY	0.51	1,234
	03	04	Roads/Parking/Curbs/Walks		SY		
	03	05	Fencing		LF		
	03	06	Electrical Distribution		LF		
	03	07	Telephone/Communication Distribution		LF		
	03	08	Water/Sewer/Gas Distribution		LF		
	03	09	Steam and Condensate Distribution		LF		
	03	10	Fuel Line Distribution		LF		
	03	11	Storm Drainage/Subdrainage		LF		
	03	12	Permanent Cover Structure Over Containment Area		SF		
	03	13	Development of Borrow Pit/Haul Roads		ACR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	03	14		Fuel Storage Tanks (New)		EA		
	03	9X		Other (Use Numbers 90-99)				
	04			**ORDNANCE AND EXPLOSIVE - CHEMICAL WARFARE**				
	04	01		Ordnance Removal and Destruction		ACR		
	04	9x		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF		
	05	02		Floodwalls		SF		
	05	03		Levees		LF		
	05	04		Terraces and Benches		LF		
	05	05		Channels/Waterways (Soil/Rock)		LF		
	05	06		Chutes or Flumes		LF		
	05	07		Sediment Barriers		LF		
	05	08		Storm Drainage		LF		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	12		Earthwork		CY		
	05	13		Erosion Control		ACR		
	05	14		Development of Borrow Pit/Haul Roads		ACR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA		
	06	02		Subsurface Drainage/Collection		LF		
	06	03		Slurry Walls		SF		
	06	04		Grout Curtain		SF		
	06	05		Sheet Piling		SF		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	09		Development of Borrow Pit/Haul Roads		ACR		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF		
	07	02		Gas/Vapor Collection Well System		EA		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asphalt		ACR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	07		Development of Borrow Pit/Haul Roads		ACR		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Pump System		ACR		
	09	08		Development of Borrow Pit/Haul Roads		ACR		
	09	9x		Other (Use Numbers 90-99)				
	10			**DRUMS/TANKS/STRUCTURES/MISCELLANEOUS**				
	10	01		Drum Removal		EA		
	10	02		Tank Removal		EA		
	10	03		Structure Removal		SF		
	10	04		Asbestos Abatement		SF		
	10	05		Piping and Pipeline Removal		LF		
	10	06		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	10	07		Miscellaneous Items		ACR		
	10	08		Contaminated Paint Removal		SF		
	10	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Sequencing Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Construction of Permanent Plant Facility		EA		
	11	9x		Other (Use Numbers 90-99)				

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	**12**			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic Oxidation, UV Ozone,		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process (BCDP)		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Construction of Permanent Plant Facility		EA		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		
	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction	27,800	CY	16.22	451,031
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging	37,400	MGA	1.07	39,857
	13	50		Construction of Permanent Plant Facility		EA		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Construction of Permanent Plant Facility		EA		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		
	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Construction of Permanent Plant Facility		EA		
	15	9x		Other (Use Numbers 90-99)				
	16			**RESERVED FOR FUTURE USE**				
	17			**DECONTAMINATION AND DECOMMISSIONING (D&D)**				
	17	01		Pre-Decommissioning Operations		SF		
	17	02		Facility Shutdown Activities		SF		
	17	03		Procurement of Equipment and Material		SF		
	17	04		Dismantling Activities		SF		
	17	05		Research and Development (R&D)		SF		
	17	06		Spent Fuel Handling		SF		
	17	07		Hot Cell Cleanup		SF		
	17	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Construction of Permanent Disposal Facility		EA		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees and Taxes		TON		
	18	23		Mixed Waste Storage Fees and Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	19			**DISPOSAL (COMMERCIAL)**				
	19	20		Container Handling	30	EA	60	1,800
	19	21		Transportation to Storage/Disposal Facility		TON		
	19	22		Disposal Fees and Taxes		TON		
	19	23		Mixed Waste Storage Fees and Taxes		TON		
	19	9x		Other (Use Numbers 90-99)	1	LS	250	250
	20			**SITE RESTORATION**				
	20	01		Earthwork	2,420	CY	1.86	4,501
	20	02		Permanent Markers		EA		
	20	03		Permanent Features		EA		
	20	04		Revegetation and Planting	3	ACR	1,427	4,281
	20	05		Removal of Barriers		EA		
	20	9x		Other (Use Numbers 90-99)				
	21			**DEMOBILIZATION**				
	21	01		Removal of Temporary Facilities		EA		
	21	02		Removal of Temporary Utilities	1	EA	546	546
	21	03		Final Decontamination		EA		
	21	04		Demobilization of Construction Equipment and Facilities	1	EA	1,059	1,059
	21	05		Demobilization of Personnel		EA		
	21	06		Submittals	1	EA	5,788	5,788
	21	07		Construction Plant Takedown		EA		
	21	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				578,801

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
34XXX				**HTRW POST CONSTRUCTION AND FINANCIAL CLOSEOUT ACTIVITIES**				
341XX				**FISCAL/FINANCIAL CLOSE ACTIVITIES**				
342XX				**HTRW OPERATION AND MAINTENANCE (POST CONSTRUCTION)**				
	02			**MONITORING, SAMPLING, TESTING, AND ANALYSIS**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling		EA		
	02	04		Monitoring Wells	28	EA	350	9,800
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing		EA		
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-site Laboratory Facilities		EA		
	02	14		Off-site Laboratory Facilities		EA		
	02	9X		Other (Use Numbers 90-99)	1	LS	970,005	970,005
	03			**SITEWORK**				
	03	04		Roads/Parking/Curbs/Walks		SY/YR		
	03	05		Fencing		LF/YR		
	03	06		Electrical Distribution		LF/YR		
	03	07		Telephone/Communication Distribution		LF/YR		
	03	08		Water/Sewer/Gas Distribution		LF/YR		
	03	09		Steam and Condensate Distribution		LF/YR		
	03	10		Fuel Line Distribution		LF/YR		
	03	11		Storm Drainage/Subdrainage		LF/YR		
	03	12		Permanent Cover Structure Over Contaminated Area		SF/YR		
	03	14		Fuel Storage Tanks (New)		EA/YR		
	03	9X		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF/YR		
	05	02		Floodwalls		SF/YR		
	05	03		Levees		LF/YR		
	05	04		Terraces and Benches		LF/YR		
	05	05		Channels/Waterways (Soil/Rock)		LF/YR		
	05	06		Chutes or Flumes		LF/YR		
	05	07		Sediment Barriers		LF/YR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	05	08		Storm Drainage		LF/YR		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	13		Erosion Control		ACR/YR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA/YR		
	06	02		Subsurface Drainage/Collection		LF/YR		
	06	03		Slurry Walls		SF/YR		
	06	04		Grout Curtain		SF/YR		
	06	05		Sheet Piling		SF/YR		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF/YR		
	07	02		Gas/Vapor Collection Well System		EA/YR		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY/YR		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR/YR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		
	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asph		ACR/YR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND CONTAINMENT**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	09	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Seq Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting (Soil Pile Bioremediation)		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	11	9x		Other (Use Numbers 90-99)				
	12			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic)		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis (UV Oxidation)		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction	27,800	CY	34.74	965,676
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		
	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging	37,400	MGA	17.15	641,409
	13	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	15	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		
	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Post Construction O&M of Permanent Disposal Fac		EA/YR		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees & Taxes		TON		
	18	23		Mixed Waste Storage Fees & Taxes		TON		
	18	9x		Other (Use Numbers 90-99)	1	LS	30,000.00	30,000
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				2,616,890

APPENDIX D
COST REPORTING TEMPLATES

The following pages provide example summary sheets to report or estimate capital, O&M, and periodic costs, either RA or post-RA, and templates for HCAS data entry using the HTRW RA WBS for RA capital and RA operating costs that are required for input. These sheets should be filled in with the required information and submitted (1 copy each) to the USACE HTRW Center of Expertise and HQ USACE. Also provided is the HTRW O&M WBS shown to the third (subsystem) level with columns for input of quantities and costs. The forms are available electronically for downloading at *http://www.environmental.usace.army.mil/info/technical/cost/cost.html*. Mailing addresses are as follows:

U.S. Army Corps of Engineers
HTRW Center of Expertise (CENWO-HX-T)
12565 West Center Road
Omaha, NE 68144-3869

U.S. Army Corps of Engineers
Headquarters (_____________)
441 G Street, NW
Washington, D.C. 20314

CAPITAL COST SUMMARY

Site: ____________________
Location: ____________________
Phase: ____________________
Base Year: ____________________
Date: ____________________

Description: ____

DESCRIPTION	QUAN-TITY	UNIT	UNIT COST	TOTAL	NOTES

O&M COST SUMMARY

Site: ______________________ **Description:** ____
Location: ______________________ ____
Phase: ______________________ ____
Base Year: ______________________ ____
Date: ______________________ ____

DESCRIPTION	QUAN-TITY	UNIT	UNIT COST	TOTAL	NOTES

PERIODIC COST SUMMARY

Site: ______________________ **Description:** ____
Location: ______________________ ____
Phase: ______________________ ____
Base Year: ______________________ ____
Date: ______________________ ____

DESCRIPTION	QUAN-TITY	UNIT	UNIT COST	TOTAL	NOTES

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 1)

Project Information

Project Name ____________
Project Number ____________
Project Phase (Select one)
- Studies and Design ______
- Remedial Action ______
- Operations and Maintenance ______

Project Note (Describe the project)

____
____
____
____
____
____
____

Contract Information

Contract Number ____________
Managing Organization ____________
Organization Name ____________
Site Owner ____________
Other ID Number ____________
Prime Contractor ____________
Contract Type (Select one)
- Cost + Award Fee ______
- Cost + Base + Award Fee ______
- Cost + Fixed Fee ______
- Cost + Incentive Award ______
- Fixed Price ______
- Not Availiable ______
- Other ______

Procurement Type (Select one)
- Two Step Sealed Bid ______
- Sealed Bid (IFB) ______
- Competitive Negotiation (RFP) ______
- Sole Source (SSC) ______
- Other ______

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 2)

Site Information

State/Country __________
Installation __________
Site Name __________
Site Number __________
EPA Region __________
Current Use (Select one)
- Installation Operation _____
- Industry Operation _____
- Residential _____
- Recreational _____
- Wildlife Refuge _____
- Waste Disposal _____
- Administrative Office _____
- Commercial _____
- Other _____
- Unknown _____

Future Use (Select one)
- Installation Operation _____
- Industry Operation _____
- Residential _____
- Recreational _____
- Wildlife Refuge _____
- Waste Disposal _____
- Administrative Office _____
- Commercial _____
- Other _____
- Unknown _____

Point of Contact

	Data Entry Person	POC#2	POC#3
Title/Role			
Organization			
Name			
Address			
City, State			
Zip			
Telephone			
Fax			
Email			

Enter up to 3 POC's.

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 3)

Profile - General Characteristics

Regulatory Class
- CERCLA ________
- RCRA ________
- Other ________
- Unknown ________

National Priority List
- Yes ________
- No ________

Wetland
- Yes ________
- No ________

Flood Plain
- Yes ________
- No ________

Public Concern
- Low ________
- High ________

Historical/Archoelogical
- Yes ________
- No ________

Innovative Technology
- Yes ________
- No ________

Size of Exclusion Zone (Acres) ________

Size of Area (Acres) ________

Profile - Contaminants/Technical Approach

Site Type	**Media**	**Contaminant**	**Technical Approach**
AG Storage Tanks	Air	Nonhal VOC's	CWM/OEW Remvl
UG Storage Tanks	Equipment/Mach	Halogenated VOC's	Surf Water Control
Drums/Cont <250 GA	Groundwater	Nonhal Semi VOC's	Grnd Water Control
Unauth Disposl Area	Liquid	Halogen Semi VOC's	Air/Gas Control
Facil/Bldgs	Surface Water	Fuels	Solids Contain
Fire Train/Open Burn	Sediment	Inorganics	Liq/Sed/Sludge Cntrl
Firing Rnge/Open Det	Sludge	Low Lev Rad Waste	Drums/Tanks Remvl
Pit/Trench	Soil	High Lev Rad Waste	Biological Treatment
Surf Impnd/Lagoons	Solid/Debris	Low Rad Mixed Wst	Chemical Treatment
Lakes/Ponds/Swamp	Struct Bldg Matls	TRU Waste	Physical Treatment
Landfill	Other	CWM/OEW	Thermal Treatment
Ocean		Asbestos	Stab/Fix/Encap
Rivers/Streams		Unknown	Decon & Decommish
Spill/Emerg Resp		Other	Disposal (Not Comm)
Waste Pile			Disposal Commercial
Other			Other

Pick as many Profile combinations as necessary:

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 4)

Cost

Start Date ____________________
End Date ____________________
Number of Mods __________
Reasons for Mods (Select those applicable)
- Administrative __________
- Changes for Time or Cost __________
- Changes Requested by Government Authority __________
- Design Deficiency __________
- Differing Site Conditions __________
- Funding Level Change __________
- New Federal Regulation __________
- Other Changes __________
- Suspension or Termination of Work __________
- Value Engineering Change __________
- Variations in Estimated Quantities __________
- Variations Not Readily Identifiable During Design __________

Cost
- Award Amount ____________________
- Actual Amount ____________________
- Cost Variance ____________________

Cost Breakdown

See next sheets.

The HCAS Cost Breakdown is structured in accordance with the February 1996 "HTRW Remedial Action Work Breakdown Structure (RA WBS)" and "HTRW O&M Work Breakdown Structure (O&M WBS)".

The next sheets show the RA WBS and O&M WBS to the Third Level as required for the HCAS cost report portion of the "RA Report".

The costs reported shall be "Burdened Costs", meaning that contractor markups, general requirements, overhead, and profit shall be included in the costs.

The complete RA WBS and O&M WBS to the Fourth Level is at:
http://www.FRTR.gov/cost/ec2/wbs1.html

The HCAS 3.1 software can be downloaded from:
http://www.FRTR.gov/cost/ec2/index.html

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
33XXX				**HTRW CONSTRUCTION ACTIVITIES**				
331XX				**HTRW REMEDIAL ACTION (Capital and Operating)**				
	01			**MOBILIZATION AND PREPARATORY WORK**				
	01	01		Mobilization of Construction Equipment and Facilities		EA		
	01	02		Mobilization of Personnel		EA		
	01	03		Submittals/Implementation Plans		EA		
	01	04		Setup/Construct Temporary Facilities		EA		
	01	05		Construct Temporary Utilities		EA		
	01	06		Temporary Relocations of Roads/Structures/Utilities		EA		
	01	07		Construction Plant Erection		EA		
	01	08		Institutional Controls		EA		
	01	09		Alternate Water Supply		EA		
	01	10		Population Relocation		EA		
	01	9X		Other (Use Numbers 90-99)				
	02			**MONITORING, SAMPLING, TESTING, AND ANALYSIS**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling		EA		
	02	04		Monitoring Wells		EA		
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing		EA		
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-Site Laboratory Facilities		EA		
	02	14		Off-Site Laboratory Facilities		EA		
	02	9X		Other (Use Numbers 90-99)				
	03			**SITEWORK**				
	03	01		Demolition		SY		
	03	02		Clearing and Grubbing		ACR		
	03	03		Earthwork		CY		
	03	04		Roads/Parking/Curbs/Walks		SY		
	03	05		Fencing		LF		
	03	06		Electrical Distribution		LF		
	03	07		Telephone/Communication Distribution		LF		
	03	08		Water/Sewer/Gas Distribution		LF		
	03	09		Steam and Condensate Distribution		LF		
	03	10		Fuel Line Distribution		LF		
	03	11		Storm Drainage/Subdrainage		LF		
	03	12		Permanent Cover Structure Over Containment Area		SF		
	03	13		Development of Borrow Pit/Haul Roads		ACR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	03	14		Fuel Storage Tanks (New)		EA		
	03	9X		Other (Use Numbers 90-99)				
	04			**ORDNANCE AND EXPLOSIVE - CHEMICAL WARFARE**				
	04	01		Ordnance Removal and Destruction		ACR		
	04	9x		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF		
	05	02		Floodwalls		SF		
	05	03		Levees		LF		
	05	04		Terraces and Benches		LF		
	05	05		Channels/Waterways (Soil/Rock)		LF		
	05	06		Chutes or Flumes		LF		
	05	07		Sediment Barriers		LF		
	05	08		Storm Drainage		LF		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	12		Earthwork		CY		
	05	13		Erosion Control		ACR		
	05	14		Development of Borrow Pit/Haul Roads		ACR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA		
	06	02		Subsurface Drainage/Collection		LF		
	06	03		Slurry Walls		SF		
	06	04		Grout Curtain		SF		
	06	05		Sheet Piling		SF		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	09		Development of Borrow Pit/Haul Roads		ACR		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF		
	07	02		Gas/Vapor Collection Well System		EA		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asphalt		ACR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	07		Development of Borrow Pit/Haul Roads		ACR		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Pump System		ACR		
	09	08		Development of Borrow Pit/Haul Roads		ACR		
	09	9x		Other (Use Numbers 90-99)				
	10			**DRUMS/TANKS/STRUCTURES/MISCELLANEOUS**				
	10	01		Drum Removal		EA		
	10	02		Tank Removal		EA		
	10	03		Structure Removal		SF		
	10	04		Asbestos Abatement		SF		
	10	05		Piping and Pipeline Removal		LF		
	10	06		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	10	07		Miscellaneous Items		ACR		
	10	08		Contaminated Paint Removal		SF		
	10	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Sequencing Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Construction of Permanent Plant Facility		EA		
	11	9x		Other (Use Numbers 90-99)				

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	**12**			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic Oxidation, UV Ozone,		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process (BCDP)		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Construction of Permanent Plant Facility		EA		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		
	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction		CY		
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging		MGA		
	13	50		Construction of Permanent Plant Facility		EA		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Construction of Permanent Plant Facility		EA		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		
	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Construction of Permanent Plant Facility		EA		
	15	9x		Other (Use Numbers 90-99)				
	16			**RESERVED FOR FUTURE USE**				
	17			**DECONTAMINATION AND DECOMMISSIONING (D&D)**				
	17	01		Pre-Decommissioning Operations		SF		
	17	02		Facility Shutdown Activities		SF		
	17	03		Procurement of Equipment and Material		SF		
	17	04		Dismantling Activities		SF		
	17	05		Research and Development (R&D)		SF		
	17	06		Spent Fuel Handling		SF		
	17	07		Hot Cell Cleanup		SF		
	17	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Construction of Permanent Disposal Facility		EA		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees and Taxes		TON		
	18	23		Mixed Waste Storage Fees and Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	19			**DISPOSAL (COMMERCIAL)**				
	19	20		Container Handling		EA		
	19	21		Transportation to Storage/Disposal Facility		TON		
	19	22		Disposal Fees and Taxes		TON		
	19	23		Mixed Waste Storage Fees and Taxes		TON		
	19	9x		Other (Use Numbers 90-99)				
	20			**SITE RESTORATION**				
	20	01		Earthwork		CY		
	20	02		Permanent Markers		EA		
	20	03		Permanent Features		EA		
	20	04		Revegetation and Planting		ACR		
	20	05		Removal of Barriers		EA		
	20	9x		Other (Use Numbers 90-99)				
	21			**DEMOBILIZATION**				
	21	01		Removal of Temporary Facilities		EA		
	21	02		Removal of Temporary Utilities		EA		
	21	03		Final Decontamination		EA		
	21	04		Demobilization of Construction Equipment and Facilities		EA		
	21	05		Demobilization of Personnel		EA		
	21	06		Submittals		EA		
	21	07		Construction Plant Takedown		EA		
	21	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
34XXX				**HTRW POST CONSTRUCTION AND FINANCIAL CLOSEOUT ACTIVITIES**				
341XX				**FISCAL/FINANCIAL CLOSE ACTIVITIES**				
342XX				**HTRW OPERATION AND MAINTENANCE (POST CONSTRUCTION)**				
	02			**MONITORING, SAMPLING, TESTING, AND**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling		EA		
	02	04		Monitoring Wells		EA		
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing		EA		
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-site Laboratory Facilities		EA		
	02	14		Off-site Laboratory Facilities		EA		
	02	9X		Other (Use Numbers 90-99)		EA		
	03			**SITEWORK**				
	03	04		Roads/Parking/Curbs/Walks		SY/YR		
	03	05		Fencing		LF/YR		
	03	06		Electrical Distribution		LF/YR		
	03	07		Telephone/Communication Distribution		LF/YR		
	03	08		Water/Sewer/Gas Distribution		LF/YR		
	03	09		Steam and Condensate Distribution		LF/YR		
	03	10		Fuel Line Distribution		LF/YR		
	03	11		Storm Drainage/Subdrainage		LF/YR		
	03	12		Permanent Cover Structure Over Contaminated Area		SF/YR		
	03	14		Fuel Storage Tanks (New)		EA/YR		
	03	9X		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF/YR		
	05	02		Floodwalls		SF/YR		
	05	03		Levees		LF/YR		
	05	04		Terraces and Benches		LF/YR		
	05	05		Channels/Waterways (Soil/Rock)		LF/YR		
	05	06		Chutes or Flumes		LF/YR		
	05	07		Sediment Barriers		LF/YR		
	05	08		Storm Drainage		LF/YR		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	05	10		Pumping/Draining/Collection		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	05	11		Transport to Treatment Plant		MGA		
	05	13		Erosion Control		ACR/YR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA/YR		
	06	02		Subsurface Drainage/Collection		LF/YR		
	06	03		Slurry Walls		SF/YR		
	06	04		Grout Curtain		SF/YR		
	06	05		Sheet Piling		SF/YR		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF/YR		
	07	02		Gas/Vapor Collection Well System		EA/YR		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY/YR		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR/YR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		
	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asph		ACR/YR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND CONTAINMENT**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	09	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Seq Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting (Soil Pile Bioremediation)		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	11	9x		Other (Use Numbers 90-99)				
	12			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic)		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis (UV Oxidation)		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		
	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction		CY		
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		
	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging		MGA		
	13	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		
	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	15	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		
	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Post Construction O&M of Permanent Disposal Fac		EA/YR		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees & Taxes		TON		
	18	23		Mixed Waste Storage Fees & Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				