EXECUTIVE SUMMARY

LABOR MARKET STUDY of Hazardous Waste Workers and Associated Emergency Responders

Prepared for National Institute of Environmental Health Sciences and Environmental Protection Agency

Prepared by
Ruth Ruttenberg & Associates, Inc.
Ruth Ruttenberg, Deborah Weinstock, and Lina Santamaria

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Cleaning up the nation's hazardous waste sites will require the labor of millions of workers, in all fifty states. To better undestand this labor market, the Environmental Protection Agency and the National Insitute of Environmental Health Sciences contracted with Ruth Ruttenberg & Associates, Inc. (RRA) to describe on-going hazardous waste cleanup activities and make predictions for future work force needs. Detailed data on the existing labor force were obtained through analysis of eighty thousand certified payroll records, encompassing approximately $40 millionof earnings and two million hours of work. From such a "real experience" data base, labor market profiles have been established and projections made through the year 2010.

The detailed data upon which this study is based provide important information to those who do job planning and job training associated with the cleanup of hazardous materials. The RRA data base of certified payrolls in one which can be expanded over time to remain current and to more comprehensively cover the nation's cleanup activities. The data are also a source for future research, a rich source of actual experience from which a wide variety of analyses and projections can flow.

Findings reported in the study are by site, by craft, and by legislative jurisdiction; (i.e., National Priorities List, RCRA, Department of Energy, Department of Defense, Underground Storage Tanks, and State/Private sites). Findings include gros payroll, average hourly earnings, percent overtime, the communities in which workers reside, and relative intensity of each craft used. Intensity of craft is determined largely by its share of gross payroll. For some sites there are lists of equipment and personal protective equipment used. The following are highlights of the findings and projections:

- **APPROXIMATELY 3.5 MILLION JOB YEARS, IN ALL FIFTY STATES, ARE ASSOCIATED WITH DIRECT CLEANUP OF THE NATION'S HAZARDOUS WASTE SITES. THIS REPRESENTS 5.5 BILLION LABOR HOURS FOR ON-SITE REMEDIAL ACTION AND ASSOCIATED OPERATIONS AND MAINTENANCE ACTIVITIES.**
- **THE FOUR MAJOR CATEGORIESOF WORKERSAT HAZARDOUS WASTE SITES ARE CONSTRUCTION, INDUSTRIAL, TRANSPORTATION, AND EMERGENCY RESPONSE.**
- **MORE THAN 60 PERCENT OF ON-SITE REMEDIATION WORK (EXCLUDING OPERATIONS & MAINTENANCE) IS DONE BY THREE CRAFTS -- EQUIPMENT OPERATORS, LABORERS, AND TRUCK DRIVERS. EIGHT CRAFTS -- OPERATORS, LABORERS, TRUCK DRIVERS, CARPENTERS, ELECTRICIANS, MECHANICS, PLUMBERS AND PIPE FITTERS, AND IRON WORKERS -- ACCOUNT FOR 80 PERCENT OF THE WORK.**
- **AVERAGE HOURLY EARNINGS ACROSS 17 SITES STUDIED WAS $18.40.**
- **TYPICALLY 50-80 PERCENT OF PAYROLL WENT TO ON- SITE WORKERS WHO LIVE WITHIN 25 MILES OF THE SITE AT WHICH THEY WORK.**
- **IN THE PERIOD 1990-2000 ALONE, DEMAND FOR REMEDIAL ACTION WORKERS IS EXPECTED TO GROW BY 60 PERCENT. MORE AND MORE HAZARDOUS WASTE WORKERS ARE GOING TO BE NEEDED, ESPECIALLY OVER THE NEXT FIFTEEN YEARS, TO SUPPORT SCHEDULED CLEANUP ACTIVITIES.**
- **MORE EMPLOYMENT EPISODES, PERHAPS THREE TIMES AS MANY, WILL OCCUR FOR HAZMAT WORK AS THERE**

ARE JOB YEARS ESTIMATED, BECAUSE OF PEAK DEMANDS FOR WORKERS THROUGH A REMEDIATION PROCESS.

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Any errors or opinions expressed herein are, of course, solely the responsibility of Ruth Ruttenberg & Associates, Inc.

Ruth Ruttenberg, Deborah Weinstock, and Lina Santamaria
Ruth Ruttenberg & Associates, Inc.

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Section I: Overview

Cleaning up the nation's hazardous waste sites is an enormous undertaking, requiring the efforts of millions of workers and hundreds of billions of dollars. On-site remedial action alone, 1990-2010, will utilize three million job years, or 4.5 billion hours, of labor. Operations and maintenance work will require another one billion labor hours.

Who are the workers that the nation is relying on to do the cleanup work? They are construction workers, industrial workers, transportation workers, and emergency responders. Many industrial and construction workers have been trained in hazardous materials health and safety and will bring the skills of their trades to hazardous waste site cleanup. Additional individuals are gaining skills both in hazardous materials handling and in the specific industrial and construction skills necessary to cap a landfill, monitor pump and treat activities, or remove underground storage tanks. Hundreds of thousands of emergency personnel will respond to spills, leaks, fires, explosions, and other hazardous materials incidents. Hazardous waste cleanup is labor intensive.

A better understanding of the labor market for hazardous waste workers can make the planning of environmental cleanup more efficient, and safety and health training more targeted and timely. The Worker Education and Training Program at the National Institute of Environmental Health Sciences (NIEHS) and the Environmental Protection Agency (EPA), Office of Solid Waste and Emergency Response contracted with Ruth Ruttenberg & Associates, Inc. (RRA) to study the labor market associated with hazardous waste cleanup work. The actual experience at a number of hazardous waste sites across the nation have been recorded from certified payroll information. RRA has developed an extensive data base from these payrolls and has analyzed a broad range of other labor market data to create a profile of the current cleanup work force and to make projections of future work. The focus of this study is the construction, industrial, transportation, and emergency response workers necessary to clean up hazardous waste sites.

OVERVIEW OF HAZARDOUS WASTE CLEANUP

For more than 40 years the disposal of hazardous waste at landfills, industrial plants, military bases, and other locations across the country has contaminated many thousands of sites and nearby communities. Environmental and public health risks identified at these hazardous waste sites include contaminated air, direct contact with hazardous waste, contaminated drinking water, ecological damage, fire and explosion hazards, exposure through the food chain, and contaminated groundwater, soil, and surface water.[1]

How Many Sites Are There?

Hundreds of thousands of sites must be cleaned up. There are approximately 1285 sites on the National Priorities List and tens of thousands of sites regulated by RCRA. There are thousands of sites under the jurisdiction of the Department of Energy and the Department of Defense. More than 295,000 underground storage tanks require closure or removal and there are as many as 425,000 state and private sites.

The Cleanup Process is Complex

The cleanup of a hazardous waste site many take many years. The process is arduous and complex. Preparation for the actual remediation of soil or groundwater may occur only after years of investigations and negotiations. Much time and money has been spent on site investigations and feasibility studies, costing out each remedy and listing the advantages and disadvantages of each treatment plan.

Upon first notification of an incident or potentially hazardous site, the appropriate regulatory body performs a preliminary assessment (PA) to determine whether action is necessary. If the PA indicates an emergency requiring immediate or short-term action to reduce risk to the public, a removal action is conducted to stabilize or clean up the site. After the removal action, if a hazard remains, a site inspection (SI) is conducted to determine if a site warrants scoring under the Hazard Ranking System (HRS) -- a system that scores sites on the potential effects from contamination on human health and the environment. Those sites which score 28.5 and higher are proposed for the National Priorities List (NPL) of EPA.

If a site is placed on the NPL, an in-depth planning and investigation phase -- called remedial investigation (RI)/feasibility study (FS) -- takes place. The results of the RI/FS and the rationale for selecting a remedy are required by EPA and are documented in a Record of Decision (ROD). In some instances, several RI/FSs and RODs are needed for different operable units -- portions of the site -- which require separate cleanup actions. RODs specify the technology type deemed to be the appropriate remedy for a site, and after many years of experience, and scientific and engineering evaluations of performance data on technology use, EPA has developed guidelines for the most appropriate remedies for treating specific types of sites. These preferred treatments for common categories of sites are referred to as presumptive remedies. Presumptive remedies are not available for all contaminant types but pilots underway should help make remedy selection and, thereby, the writing of RODs increasingly more efficient. RODs also list the alternatives that were considered, and the pros and cons of each selected alternative.

Using the ROD, detailed engineering specifications for the selected cleanup alternative are developed. These designs are then used to solicit bids for remedial action (RA). Operations and maintenance (O&M) activities, if necessary, begin at the conclusion of remedial action. O&M activities include groundwater monitoring, periodic site inspections, and other activities designed to ensure continued effectiveness of the remedial actions.

Sites which do not rank high enough on the HRS still need to be cleaned up. These are typically addressed through state programs, which go through similar steps.

As cleanup proceeds, many different crafts are needed on-site for the complex array of activities which occur over the course of cleanup. Usually a range of tasks are performed simultaneously. For example, at Lipari Landfill work that was going on in March 1990 included excavation, foundations, and concrete work for buildings and tanks. These tasks lasted through October 1990, while in June of that year work began on the plant plumbing and lasted until mid-September. Also in July, work began on the heating, ventilation, and air conditioning duct work for the plant, and in August outside tanks were erected. Well drilling activities occurred throughout this time. In addition to the main contractor, there was major work done by the Army Corps of Engineers and at least twenty-two individual subcontractors. More than a dozen labor crafts were involved.

Another example of the multiple on-going activities at a complex site is the cleanup at Paducah Gaseous Diffusion Plant. In the spring of 1994 site decontamination pads were built, access control fences were installed, drilling and environmental restoration staging activities were underway as well as plume well installation and clamshell building construction. In just two and a half months, no fewer than 15 different crafts and at least thirteen contractors performed work.

A prime or general contractor is responsible for getting the cleanup done. In addition there may be a company which acts as project coordinator. The general contractor hires subcontractors, and those subcontractors may in turn, hire others. Pinpointing exactly what company is working on what part of what task and when -- and for which company workers are doing actual remediation work -- may be challenging.

The focus of this study is on-site containment and on-site treatment. Further research could provide estimates for both ex-situ activities for containment and treatment and also employment associated with the building of treatment equipment and even pre-fab buildings off-site which later come on-site for cleanup purposes. The on-site craft labor employment studied here is only one portion of the job opportunities associated with hazardous waste cleanup work.

Economic Impact.

Hazardous waste cleanup not only improves the environment, but it also introduces new economic opportunities to a community. Hazardous waste cleanup is a growing sector of the economy. In the first three years of the decade alone, waste management activities grew by more than 40 percent.[2] A draft economic impact study done for the Environmental Protection Agency in 1994 found that for every $1 of Superfund expenditure, $3.10 of goods and services were generated.[3] Over the period FY81-FY92, this multiplier meant that $7.6 billion of Superfund procurement had total direct and indirect economic impact of $23.5 billion.[4] The overall impact that cleanup of hazardous waste will have on the U.S. economy is difficult to project since not all sites have been identified; many site assessments have not been completed; some sites will require more or different cleanup than originally anticipated; and the longer cleanup takes, the more expensive it will likely become.[5] But if NPL cleanup is estimated to cost at least $100 billion, the direct and indirect generation of demand for goods and services associated with this aspect of Superfund, is well over $300 billion. Understanding the mechanism of how environmental restoration expenditures may positively impact community, as well as national, economic base and job generation provides important insights for coordination of economic and environmental policies.

One recent draft EPA study[6] determined that Superfund activities had created 32 jobs per million dollars spent, either directly or indirectly, for craft labor and supervisory activities, by federal contractors and manufacturers of cleanup equipment. This RRA study focuses only on those physically cleaning up the site and conservatively estimates 4.4 direct craft labor jobs associated with each million dollars spent. The portion of the cleanup dollar that goes to actual earth moving, capping, chemical treatment, pumping of contaminated ground water, etc. is likely to be more labor-intensive -- and labor-intensive with the kind of manufacturing and construction jobs that add economic base and economic growth to an area. As hazardous waste sites are remediated, land can often be returned to productive use, thus further fueling the engine of economic growth, strengthening new businesses and labor markets alike.

Is There Such a Job Category As Hazardous Waste Worker?

As hazardous waste cleanup expands and intensifies, millions of individuals will spend a portion of their working lives in the hazardous waste cleanup process. Cleanup requires a significant amount of skilled labor, but there is no formal job category that can be identified as hazardous waste worker. The Standard Industrial Classification (SIC) system of the U.S. Department of Commerce does not provide an analytic category for hazardous waste worker. The SIC system does include SIC 4953, Hazardous Waste Worker, for those responsible for the destruction of hazardous refuse. SIC 4212 includes transportation workers who haul hazardous waste. But these SIC codes are far from inclusive. There are many other individuals who work at hazardous waste sites. And if one asks these individuals to describe their job, they are more likely to say, "I am a carpenter;" "I am a heavy equipment operator;" or "I am a pipe fitter" than "I am a hazardous waste worker." These individuals may spend most of their working lives on hazardous waste sites. More likely, they will work a number of jobs within their trade -- many of them unrelated to hazardous waste remediation. Ongoing research will help to identify the degree to which those receiving hazardous materials training may increasingly focus their career on hazardous waste cleanup and the degree to which hazardous waste cleanup is but one type of job that individuals have over the course of their work life.

For the purposes of this study, anyone working at a hazardous waste site, especially if in an area requiring HAZMAT training, has been included in the data base. There are several jobs which one may not have originally characterized as HAZMAT jobs. For instance, people hired to fence a site are considered HAZMAT workers for the purposes of this study. They are listed on the certified payrolls of cleanup contractors and subcontractors, and they usually require HAZWOPER training. The same is true for those who build the pump and treat systems, roads, or do landscaping after the waste is removed. The hazardous waste site remediation process has had a direct impact on producing these jobs. One does not need to wear personal protective clothing to be performing HAZMAT work. Also included, but often harder to fully identify, are emergency responders who often work off-site and transportation workers who move hazardous waste off-site for treatment or containment.

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INTRODUCTION TO THIS STUDY AND THE DATA UPON WHICH IT IS BASED

The objective of this study is to describe and project the number and types of jobs needed to clean up the nations hazardous waste sites. This was accomplished using detailed data from the existing U.S. hazardous waste remediation labor force. The focus of data collection was federal cleanups, because they provide detailed Davis Bacon certified payrolls which catalog job categories, hours, and pay. These federal sites include those under the responsibility of EPA, DOE, and DOD.

This study has pioneered the use of very detailed certified payroll records to document real experience in expenditures of time and money at hazardous waste cleanup sites. The data document differences and similarities of cleanup sites across the country -- in labor mix, earnings, and scheduling of work. From such a "real experience" data base, more accurate labor market profiles can be established and more solidly based projections can be made. (See Appendix I for detailed Methodology.)

Data obtained from certified payrolls included standard and overtime hours worked, hourly pay, and job category. For most of the sites studied, certified payrolls were available for only a portion of the remediation work at that site. More often the payrolls for the data base represented discrete tasks such as constructing a decontamination pad, building a pump and treat system, or drilling wells.

An objective in data collection was to obtain data from sites where there had been task completions, not necessarily site completions. Some data is from the late 1980s, but most is from the mid 1990s. Time lines for task completions at specific sites were developed as part of the study process and are available on request. All numbers used in the text emanate from the RRA data base unless otherwise footnoted.

This study is based on the collection of more than 80,000 Davis-Bacon[7] payroll records from 17 sites, daily labor logs from one site[8], other labor market data from 12 sites, data from EPA's Removal Cost Management System (RCMS) for eight federal removal sites, the analysis of data on more than 20,000 state sites with data collected by EPA in conjunction with ASTSWMO, and creation of data bases and analysis from five emergency response data systems (three in Arizona, one in California, and one in New Jersey), as well as extensive review and analysis of existing studies on environmental remediation work across the United States. The detailed data upon which this study is based provides important information to those who do job planning and/or job training associated with the cleanup of hazardous waste. Data were obtained from cleanup contractors, EPA area offices, DOE field offices, and the Army Corps of Engineers. The certified payroll data base is one which can be expanded over time to remain current and also to more comprehensively cover the nation's cleanup activities. The data are also a source for future research, a rich resource of actual experience from which a wide variety of analyses and projections can flow.

Protection of Privacy

Of primary importance in the data collection process was the privacy for individual workers whose names appeared on certified payrolls. No personal identifies were used in the RRA data base -- only labor category. Copies of the forms presented to contractors and government officials outlining and assuring a privacy protocol are in Appendix V. (Also in Appendix V is a sample certified payroll form.)

Sites for Which Certified Payroll Data Were Obtained

Efforts were made to obtain certified payroll data documentation at dozens of sites across the country. The eighteen sites for which detailed data were obtained represent a broad range of site ownership, geographical location, causes of contamination, types of contamination, and types of remedial action. (See Appendix II for a brief description of each of these sites.) Had full access to data been available, more private and RCRA sites would be in the sample.

The eighteen sites which are the focus of the primary RRA data base represent sites of private industry, the U.S. Department of Defense, and the U.S. Department of Energy[9]. The sites are in thirteen states and twelve are on EPA's National Priorities List (NPL).[10] Activities which contributed to the contamination at these sites include landfills, surface impoundments, wellfields, leaking containers, asbestos hazards, radiological tailings, and waste oil. Four sites are landfills; four are uranium mill tailing remediation sites; and the other ten include a mix of activities. A broad range of remedial action categories are represented in the data base: [11] five sites used institutional controls, including monitoring, access restriction, and/or alternate water supplies; four sites used on-site containment as a remedy; at least eight sites used water collection/treatment/discharge; two sites used oil/sediment removal, low intensity treatment, and site restoration; four sites used soil/sediment removal, high intensity treatment, ash disposal, and site restoration; at least three sites used in-situ treatment; nine sites used soil/sediment removal and landfilling; and one site used water collection/discharge to existing facility. (See Tables B & C.)

The sites studied are both small and large -- ranging from $500,000 at Cherokee County to more than $14 million at BROS. Studied were specific tasks in the cleanup processes at each of the 18 sites. Only at the Durango UMTRA site did RRA obtain 100 percent of the certified payrolls for 100 percent of the cleanup work, from beginning of remedial action through completion. Because some of the sites are particularly large and complex and because many of them still have cleanup tasks pending, payroll data are for only specific tasks over specific months. RRA obtained data for as much as 75 percent of payroll, as at Lipari, but in other instances, the data obtained by RRA represented only 15 percent of total estimated payroll at a site.

The eighteen sites which make up the primary RRA data base are:

- California Sacramento Army Depot
- Colorado Durango Uranium Mill Tailings Action (UMTRA) Site
- Colorado Grand Junction UMTRA Site
- Colorado Rifle UMTRA Site
- Florida Hollingsworth Solderless Terminal Company
- Kansas Cherokee County, Galena Subsite
- Kentucky Paducah Gaseous Diffusion Plant
- Louisiana Bayou Bonfouca
- Missouri Kem-Pest Laboratories
- New Jersey Bog Creek Farm
- New Jersey Bridgeport Rental & Oil Services (BROS)
- New Jersey Lipari Landfill
- New Jersey Lone Pine Landfill
- New Mexico Shiprock UMTRA Site
- Ohio New Lyme Landfill
- Pennsylvania Moyer Landfill
- Tennessee K-25 Gaseous Diffusion Plant
- Washington South Tacoma Channel, Well 12A

Sites for Which Other Than Certified Payroll Data Were Obtained

When it was not possible to obtain certified payrolls for a site, RRA obtained other labor market data, that contractors would make available. For the twelve sites where "other" data were obtained, that data included information on job descriptions, the composition of job crews, hours worked, and/or equipment used.

Ten of these sites were in California: Concord Naval Weapons Station, Embarcadero, Hunter's Point Naval Shipyard, Intel, Mather Air Force Base, McClellen Air Force Base, Pillar Point Air Force Base, Raytheon, Richmond Harbor, and a battery plant. In Missouri data came from Weldon Springs, in New Jersey from Ciba Geigy, in Ohio from Reactive Metals Inc., and in Tennessee from X-10 and Y-12 at Oak Ridge.

Sites of the EPA Removal Cost Management System

There are more than 1500 completed site cleanups in the data bases of the EPA Removal Cost Management System (RCMS). RRA was successful in obtaining data on eight sites from four EPA regions in seven states. The data available from this system include predominant category of worker, average hourly earnings, and hours worked. Removals differ from remedial action sites in that they are typically smaller with a higher level of contamination and require cleanup on an "emergency" basis.

The eight sites for which data were obtained are: Turner Seed Company in Iowa, Superior Polishing in Michigan, Bannister Road Drum in Missouri, Carolina Creosote II in North Carolina, Anderson Residential Lead in South Carolina, Chemet in Tennessee, and Bernard Neal and Martinsburg Drum Dump in West Virginia.

Sites of the EPA/ASTSWMO State and Territorial Data Base

Cleanup of the largest number of hazardous waste sites is under the jurisdiction of the states and territories. A 1994 EPA-sponsored study of these sites produced a data base of over 20,000 sites from 39 states and two territories. The sites varied considerably, with cleanup costs ranging from $1000 to $7 million. Some sites were remedial actions and some were removals. They covered a wide range of contaminants and a wide range of cleanup remedies. The data base is useful in characterizing the similarities and contrasts among sites and the ways that sites are remediated by the various states.

Data on Emergency Response Associated with Hazardous Materials Incidents

Analysis of the labor market associated with emergency response poses challenges different from the labor market for other hazardous waste workers. Few emergency responders have jobs dedicated to a single site or even to hazardous materials response alone. On-site emergency response personnel often work full time at other tasks. Off-site, usually public sector, emergency response personnel are not assigned to a specific site, and are not usually part of a dedicated HAZMAT team.

The emergency response focus of this study is to characterize, to the extent possible, how many incidents require emergency response, what the nature of these incidents is, where they occur, how long they take to resolve, what emergency response personnel are called, and the nature of injuries. These data provide important perspective on the labor needs and training needs of emergency response organizations.

Among the issues reviewed, is a frequent concern of emergency response personnel -- that many of the incidents and injuries associated with a given hazardous waste site may not occur on the site itself, but rather along a transportation corridor as materials are being transported for off-site containment or treatment. The data collected for this report concur with this concern.

Data to study emergency response to hazardous materials incidents came from Arizona, California, and New Jersey. Automated data bases on emergency response associated with hazardous materials incidents are available in only a few states. RRA was successful in obtaining automated data from the state of Arizona, which maintains three separate data bases: the Arizona Hazardous Materials Incidents Reports (AHMIR), the Emergency Response Notification System (ERNS) data sheets, and reports from the Fire Departments. The state of California, through its Office of Emergency Services on Hazardous Materials Incidents, compiles its data into an annual report, which RRA reviewed and analyzed. Six months of individual, hard copy hazardous materials incident reports of the New Jersey Department of Environmental Protection were obtained and entered into a separate data base for analysis.

Literature Review

This labor market study began with an extensive literature review. As the study proceeded, literally hundreds of documents, commentaries, and other studies were reviewed -- both for relevant data and for strengthened perspective.

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ORGANIZATION OF THIS REPORT

Section I is an introduction to the study -- describing its objectives, scope, the data bases upon which it is based, and the methods used for data collection, followed by an overview of the labor market for hazardous waste cleanup.

Section II reports on data findings and data analysis. This section is divided into three parts. First are overall findings. Second are more detailed findings and analysis on projections for the largest categories of hazardous waste cleanup; i.e., NPL and federal removal sites under the jurisdiction of Superfund, RCRA, the Department of Energy, the Department of Defense, the Underground Storage Tank program and state and private sites. Finally, other issues are presented, including the impact of remedy choice on the labor market, emergency response labor market needs, issues relating to jobs and environmental justice.

Section III interprets the findings, and moves on to projections for future hazardous materials jobs, from 1990 until 2010, as well as future needs for health and safety training.

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Section II: Findings and Data Analysis

The activities of workers at hazardous waste sites are documented in Section II. Findings from the certified payroll data base -- findings of job categories, hours worked, wages paid, residence of workers, and equipment used are presented and analyzed. These and other data are used in Section III to project future demand for hazardous waste workers and associated emergency responders.

DESCRIPTION OF LABOR SKILLS NEEDED FOR CLEANUP: A STUDY OF 18 SITES

Categories of Labor

Construction labor, industrial labor (often O&M workers), transportation workers, and emergency responders, dominate hands-on remedial action and hazardous waste activities. Hazardous waste sites differ in labor skills needed. Nearly all sites rely heavily on the work of equipment operators, laborers, and truck drivers. Other skilled labor often in demand, sometimes in significant demand, are asbestos workers, boilermakers, bricklayers, carpenters, cement workers, chemical workers, drillers, electricians, emergency responders, iron workers, machine operators, mechanics, painters, plumbers and pipe fitters, rail workers, roofers, stationary engineers, and sheet metal workers. Certified payroll records, the foundation of the RRA data base, documented the use of these and other labor categories. The RRA data base covered over two million work hours and more than $40 million of payroll. Three crafts -- operators, laborers, and truck drivers -- accounted for more than 60 percent of the payroll. Eight crafts -- operators, laborers, truck drivers, carpenters, electricians, mechanics, plumbers and pipe fitters, and iron workers -- accounted for 80 percent of the payroll. (See Table 1 and Chart 1.) Data collected included dollars spent for craft labor activities at a site (see Table D), the number of standard and overtime hours devoted to cleanup, hourly rates earned -- and sometimes the levels of personal protection used in the field, equipment used, and the towns where workers lived.

From site to site, the relative use of crafts is quite variable. (See Table 1 and E.) At a few sites plumbers and pipe fitters had a significant presence -- most notably at Lipari Landfill in New Jersey, where they accounted for 27 percent of the gross pay for the time period studied. Carpenters, who were non-existent in the certified payrolls at some sites, made up nearly 20 percent of gross pay at Paducah. Iron workers, while accounting for nearly 15 percent of the gross payroll at Paducah for the months studied, were only represented in eight of the eighteen key sites. Laborers, while present at all sites, varied in their intensity of use at a site from 3 percent at the Durango and Grand Junction UMTRA sites in

Colorado to 56 percent of gross payroll at Kem-Pest in Missouri and 70 percent of gross payroll at Hollingsworth in Florida. Operators were present at all sites, and their use ranged from 2 percent of gross pay at Takoma in Washington State to 64 percent at Shiprock. Electricians earned 20 percent of the gross pay at the South Tacoma Channel Site, and mechanics earned nearly 10 percent of gross pay at Grand Junction.

Table 1

Percent of Gross Pay by Predominant Category at 17 Sites

CATEGORY	California	Colorado			Florida	Kansas	Kentucky	Louisiana
	CASAAD	Durango	Grand Junction	Rifle	Hollingsworth	Cherokee County	Paducah	Bonfouca
Carpenter	-	-	-	1%	-	1%	19%	5%
Cement	-	-	-		-	-	2%	1%
Driver	-	30%	42%	29%	-	0%	1%	2%
Electrician	1%	-	-	1%	-	3%	6%	4%
Iron Worker	-	-	-			2%	14%	1%
Laborer	45%	3%	3%	23%	70%	35%	19%	10%
Mechanic	-	7%	9%	6%	-	-	-	0%
Operator	40%	42%	8%	35%	12%	28%	16%	19%
Plumber/ Pipe Fitter	-	-	-	-		0%	6%	4%
Other	13%	18%	38%	3%	17%	32%	16%	54%
TOTAL:	100%	100%	100%	98%	99%	101%	99%	100%

Table 1, Continued.

Percent of Gross Pay by Predominant Category at 17 Sites

CATEGORY	New Jersey			New Mexico	Missouri	Ohio	Pennsylvania	Tennessee	Washington	TOTAL
	Bog Creek	BROS	Lipari	Ship-Rock	Kem-Pest	New Lyme	Moyer	K-25	Tacoma	
Carpenter	8%	4%	5%	-	3%	1%	-	11%	14%	4%
Cement	1%	-	2%	-	-	0%	-	0%	-	0%
Driver	-	5%	1%	11%	2%	17%	-	0%	0%	10%
Electrician	10%	1%	15%	-	0%	0%	-	2%	20%	4%
Iron Worker	2%	2%	8%		-	2%	-	0%	-	2%
Laborer	12%	21%	14%	23%	56%	20%	42%	43%	26%	19%
Mechanic	0%	7%	0%	0%	-	0%	0%	0%	-	4%
Operator	27%	42%	10%	64%	8%	34%	50%	5%	2%	32%
Plumber/ Pipe Fitter	8%	2%	27%	-	-	0%	-	8%	1%	4%
Other	30%	16%	16%	1%	31%	25%	8%	31%	36%	21%
TOTAL:	98%	100%	98%	99%	100%	99%	100%	100%	99%	100%

Source: Ruth Ruttenberg & Associates, Inc. Data Base

Key:
CASAAD - Sacramento Army Depot
Hollingsworth - Hollingsworth Solderless Terminal Company
BROS - Bridgeport Rental & Oil Services

CHART 1

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

In-plant industrial workers performing on-going cleanup tasks, while not always captured in the certified payroll data, are major participants in the cleanup process. Industrial workers are employed by chemical companies, by facilities of the nuclear weapons complex, by military bases, or by companies maintaining a RCRA site. Industrial workers are often responsible for operations and maintenance. They maintain operations, monitor, and are responsible for the day to day running of plants and facilities. Major O&M activities include maintenance, reporting, sampling and analysis, project management, pump and treat, and oversight engineering. Also a critical part of the hazardous waste labor force are emergency responders -- some on site; most employed in neighboring communities and along transportation corridors.

Definition of a labor category is not always simple and because definitions may vary from site to site, there is some reporting variability from site to site. Laborers might operate equipment, do carpentry work, or drive vehicles. At some sites these workers would be identified as laborers; at others they would be identified as operators, carpenters, and drivers. For example, a company noted for its work crew models,[12] establishes some crew categories that involve only laborers but which also include hydraulic cranes. One might assume that hydraulic crane operators would be operators and not laborers. Another example would be a crew category of laborers, with the equipment used being highway trucks, when one might assume that these jobs would be assigned to truck drivers and not to laborers. Common work practice also makes job definition more complex. Over a given work day or work week, one individual may work a composite of jobs -- doing the work of a laborer for a few hours, an equipment operator for a few hours, and a truck driver or a mechanic or a carpenter for a few hours. In addition the work of truck drivers sometimes is recorded in inconsistent or incomplete ways.[13]

Wages

Data analysis from certified payrolls at the 17 sites for which payroll data were available indicated average hourly earnings of $18.40 -- including overtime, shift differential, hazard pay, etc. (See Table F.) Site averages ranged from $9.49 at Hollingsworth in Florida, where the payroll was not covered by Davis-Bacon and labor was primarily industrial and non-union, to $32.50 at Bog Creek in New Jersey where wages were higher, perhaps due to significant amounts of overtime and call pay. The other 15 sites had average hourly earnings ranging from an overall average of $12.05 at Cherokee County in Kansas to $23.85 at Sacramento Army Depot in California.

Use of Overtime

Overtime ranged from 2 percent of total hours at Shiprock in New Mexico to 24 percent of total hours at Hollingsworth in Florida. The use of overtime at the other 15 sites in the RRA data base ranged from 5 percent of total hours at Durango in Colorado to 23 percent of total hours at Kem-Pest in Missouri. The average use of overtime across the 17 sites was 16 percent of total hours worked.

Some of the data, at Lipari for example, suggest that there was a learning curve in planning for labor, and overtime hours fell over time. At other sites it appeared that overtime was affected by peak demands for certain crafts; i.e.., carpenters or electricians or pipe fitters or iron workers, whose individual jobs were for intense but rather short durations. The certified payrolls themselves, however, do not indicate the reason for overtime.

Where Workers Live

Local employment is the predominant source of cleanup labor. Residential data were available for twelve sites[14] in the

RRA data base. At most sites for which residential data were collected, the majority of payroll went to workers living within 11-25 miles of the site. Typically, 50 percent to 80 percent of the payroll went to workers who lived within 25 miles of the site. Sometimes the majority of workers lived extremely close to the site or within community boundaries. At Lipari, 65 percent of the payroll went to workers who lived within 10 miles of the site. At Shiprock, located on the Navajo Nation, over 98 percent of the payroll went to those living on the Navajo Nation; nearly 50 percent of the total was earned by those who lived within the town of Shiprock itself. On one occasion, however the majority of the work force lived at a distance. At Bog Creek, nearly 85 percent of the payroll went to workers who lived more than 50 miles from the site.

Equipment Needed For Cleanup

Equipment lists -- some quite brief others; more complete -- were obtained by RRA from five of the sites studied. (Full equipment lists are available on request.) At Lone Pine equipment lists were part of the Daily Labor Log that recorded daily site activity. Data on the type of equipment used, and the number of times and days a given piece of equipment was used, were recorded. Dozers were by far the most used piece of equipment at Lone Pine, accounting for 1530 days, or over 25 percent of total mechanical days. Backhoes --including backhoe excavator, backhoe loader, backhoe with sheer, and backhoe/loader combo -- accounted for nearly 15 percent of the total mechanical days at Lone Pine. Rollers and trucks were 13 percent each; loaders were over 6 percent, and other equipment included chippers, compactors, graders, trenchers, and water tanks.

At Bridgeport Rental & Oil Services (BROS), equipment lists were available on the frequency of use by type of equipment. Several types of backhoes were used at BROS, as well as Lone Pine. Also used at BROS were 5 different types of dozers; 20 types of loaders; 15 types of pumps, forklifts, backhoes; and several types of compressors, cranes, and trackhoes.

Data on equipment from Concord Naval Weapons Station came from an interview with the contractor (ACCI). Eighteen major pieces of equipment and miscellaneous light equipment accounted for 13,120 equipment hours spent in cleanup over a fourteen month period. Equipment needed to cleanup contaminated wetlands included low ground pressure tractors, supersuckers, dozers, excavators, a backhoe, a pressure washer, dump trucks, and pickup trucks.

Equipment lists at Weldon Spring Site Remedial Action Project were available by task. Although the first three tasks listed are the dismantling of buildings, the amount and types of equipment used varied across those three dismantling tasks. Heavy equipment for building removal included staketrucks, roll-off trucks, excavators, cranes, flatbed trucks, shears, pickers, forklifts, and backhoes. Tasks involved with quarry bulk waste removal and temporary storage required waste haul trucks, dump trucks, half-ton trucks, flatbed trucks, low boys, dozers, excavators, tractors with boom, concrete pulverizers, graders, cranes, and excavators.

An equipment list from one week of work was obtained from the Rifle UMTRA site. Many trucks, scrapers, and a few dozers were used for this job, which included the excavation and relocation of contaminated soil. (The Rifle equipment list also provided information on equipment utilization once the equipment was on site -- including truck miles, weather hours, operating hours, repair hours, and idle hours.)

An EPA review of 100 hazardous waste sites[15] found that the 10 most used pieces of equipment (in descending order) -- each used on at least one-third of the 100 sites reviewed -- were:

1. Backhoe/excavator
2. Front-end loader
3. Lowboy
4. Bulldozer
5. Generator
6. Hand tools (shovels, hammers, etc.)
7. Pressure washer/laser
8. Diaphragm pump
9. Air compressor
10. Tractor (OTR)

The next pieces of equipment used most frequently -- at 16 percent to 26 percent of the sites surveyed -- were:

1. Building tanks/pools
2. Skid steer loader
3. Forklift
4. Crane
5. Rolloff boxes
6. Drum grappler
7. Vacuum truck
8. Cutting torch
9. Nonsparking tools.

DESCRIPTION OF LABOR MARKET NEEDS BY CATEGORY OF CLEANUP SITE

Discussed below are six major categories of sites and a summary of the labor needs for each. Site categories are: Superfund, RCRA, DOE, DOD, UST, and State/Private sites.

1. Sites Regulated by EPA's Superfund Program

Superfund has two basic types of cleanups: long-term remedial actions and short-term removal actions. To perform a Superfund remedial action, EPA must go through the formal process of placing a site on its National Priorities List. In the Superfund removal program, actions are taken to mitigate immediate and significant threats, such as those stemming from contaminated drinking water or unrestricted access to hazardous waste sites. Removals are generally of a short-term and emergency nature.

A. National Priorities List

<u>Background on NPL Sites</u>

Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980 to clean up highly contaminated hazardous waste sites. CERCLA gave EPA the authority to clean up these sites or to require that the parties responsible for the hazardous waste clean them up. CERCLA established a $1.6 billion trust fund, financed primarily by taxes on crude oil and certain chemicals, for EPA to implement and pay for the program. In 1986, the Superfund Amendments and Reauthorization Act (SARA) set new requirements and authorized an $8.5 billion increase in the trust fund. In 1990, Congress reauthorized CERCLA through 1994 and added $5.1 billion to the trust fund authorization. Legislation to reauthorize Superfund is pending before the Congress.

The nation's most hazardous known waste sites are on the National Priorities List (NPL), which had 1285 sites as of April 1995. Cleanup of these Superfund sites (and most other sites as well) is a multi-step process which includes: Site Discovery, Preliminary Assessment (PA), Site Inspection (SI), listing on NPL (if applicable), Remedial Investigation/Feasibility Study (RI/FS), Record of Decision (ROD), Remedial Design (RD), Remedial Action (RA), and deletion from NPL list (if applicable). This study focuses on the labor requirements of the RA Stage.

<u>Findings About NPL Sites</u>

Findings From Certified Payrolls at NPL Sites

The 12 NPL sites which are part of the RRA data base,[16] included a broad array of site types: four landfills, three surface impoundments, two leaking containers, one wellfield, three radiological tailings, one electrical, one waste oil, two manufacturing, one metalworking. (See Table G.) In addition, four of the 13 largest Superfund sites -- representing 7 percent of the active sites FY87-93, but 40 percent of the costs -- are among those included in the RRA data base.[17]

<u>Labor Mix</u>. Detailed certified payrolls were analyzed at eleven Superfund sites in eight states, creating a data base of 60,000 records representing more than $31 million of payroll (See Table H) and 1.5 million hours of work. These sites represented a broad array of contaminant types and were a mix of private and federal facilities, ranging from relatively small to extremely large cleanup jobs.[18] Operators earned nearly $10 million, or 31 percent of the total gross pay;

followed by laborers, who earned, over $6 million or 19 percent of the gross pay. Other crafts, including plumbers/pipe fitters, carpenters, electricians, truck drivers, iron workers, mechanics, and cement workers, earned between one and six percent of the total gross pay at the eleven NPL sites. (See Table 2.)

As additional sites were added to the RRA data base, both Superfund and Non-Superfund, the labor mix remained relatively stable, despite the variance from one specific site to another. (See Table 1 for a breakdown of percent of gross pay by craft by site).

Table 2

Labor Mix at 11 NPL Sites, Based on Gross Pay from Certified Payrolls					
CRAFT	% OF GROSS PAY	GROSS PAY	CRAFT	% OF GROSS PAY	GROSS PAY
Operators	31%	$9,733,349	Mechanics	3%	$1,048,829
Laborers	19%	$6,017,797	Iron Workers	3%	$812,840
Plumbers/Pipe Fitters	6%	$1,820,736	Cement Workers	1%	$166,096
Electricians	5%	$1,529,572	Other Crafts[1]	24%	$7,440,163
Carpenters	5%	$1,447,798			
Truck Drivers	4%	$1,319,406	TOTAL	101%	$31,437,507

Source: Ruth Ruttenberg & Associates Inc. Data Base.

[1] Other crafts included: asbestos workers, boilermakers, bricklayers, chemical workers, painters, roofers, and sheet metal workers.

Wages. Data analysis found average hourly earnings of $20.87 -- including overtime, shift differential, hazard pay, etc. (See Table 3.) Site averages ranged from $9.49 at Hollingsworth in Florida, where the payroll was not covered by Davis-Bacon and labor was primarily industrial and non-union, to $32.50 at Bog Creek in New Jersey where wages were higher, perhaps due to significant amounts of overtime and call pay. The other nine sites had hourly earnings ranging from an overall average of $13.93 at Bonfouca to $23.85 at Sacramento Army Depot. Hourly earnings by craft ranged from an average across sites of $16.79 for laborers to $23.63 for operators.

Table 3

Average Hourly Earnings By Predominant Category of Worker at 11 NPL Sites												
Categories	California	Florida	Kentucky	Louisiana	Missouri	New Jersey			Ohio	Pennsylvania	Tennessee	Average Hourly Rate
	CASAAD	Hollingsworth	Paducah	Bonfouca	Kem-Pest	Bog Creek	BROS	Lipari	New Lyme	Moyer	K-25	
Asbestos	$10.69	-	-	-	-	-	$24.81	$22.15	-	-	$14.93	$19.58
Carpenter	-	-	$19.81	$16.60	$20.47	$25.05	$24.70	$23.21	$18.86	-	$15.79	$22.35
Cement	-	-	$19.17	$15.58	-	$21.64	-	$22.26	$19.65	-	$16.37	$19.88
Driver	$26.72	-	$16.53	$13.89	$18.48	$14.30	$18.52	$17.76	-	-	$10.87	$16.89
Electrician	$32.74	-	$21.99	$17.13	$19.20	$26.05	$21.15	$22.20	$20.53	-	$15.71	$21.76
Iron Worker	-	-	$22.08	$14.23	-	$24.02	$22.02	$21.72	$19.83	-	$16.56	$21.18
Laborer	$20.09	$9.32 (1)	$15.32	$9.50	$15.15	$24.49	$17.87	$16.60	$16.26	$17.57	$12.36	$16.79
Mechanic	-	-	-	-	-	$16.81	$17.31	$23.52	$20.50	$23.25	$17.73	$17.34
Operator	$32.35	$10.33	$19.76	$16.08	$16.25	$40.65	$24.63	$22.21	$19.04	$21.20	$15.58	$23.63
Plumber/Pipe Fitter	-	-	$23.00	$19.06	-	$25.95	$22.47	$20.83	$20.73	-	$17.77	$21.35
Average (2)	$23.85	$9.49	$18.81	$13.93	$15.55	$32.50	$20.23	$20.69	$17.41	$18.36	$14.70	$20.87

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

(1) Laborer category in this instance is primarily industrial labor rather than construction labor.
(2) Average is overall for all crafts, even those not included in this table. Bog Creek average is especially high due to issues of overtime and call pay.

Findings From Other Sites Studied: NPL

In addition to the twelve NPL sites for which certified payrolls were collected, interviews and/or site visits were conducted at other NPL sites as well. Information obtained from interviews with individuals at such sites as Ciba-Geigy, Concord Naval Weapons Station, McClellan Air Force Base, Raytheon, and Weldon Spring, was similar to information found in certified payrolls in terms of craft mix, and wages earned by workers. (Interview summaries and site specific data are available on request.)

Findings About Operations and Maintenance Activities at NPL Sites

What percent is labor of total O&M? O&M costs vary widely from site to site. They may be minimal and they may be greater than the costs of remediation. For six of the thirteen sites in Table J -- Kansas City, Langley, McClellan, two sites at Savannah River, and Twin Cities -- O&M labor as a percent of O&M costs are estimated to be between 12 percent and 40 percent, with a median of 28 percent. Work on pump and treat at Savannah River suggests that approximately one-quarter of O&M labor is for maintenance and three-quarters is for operations. A 1993 DOE study found O&M to be approximately 16 percent of total remediation costs,[19] and to be conservative in projections, this 16 percent estimate is used in this study.

A review of thirteen remediation sites (different from those in the RRA data base.) studied by EPA and DOE (See Table J),[20] from a variety of sources, found one year of O&M to cost between 4 percent and 114 percent of total capital costs, with eight or nine of the thirteen sites having total estimated 20 year O&M (undiscounted) costs greater than total capital costs. Thus, in the majority of cases, where O&M is likely to last as long as 30 years, the total O&M cost could be several times greater than the total for capital costs.

B. Federal Removals

Background on Removals

Short-term federal removal actions, often of an emergency nature, are under the jurisdiction of EPA's Superfund Program. As of March 1996 there had been 2,567 completed federal fund-lead removal actions. There have been a total of 3,766 removal actions, which may include more than one removal action per site.[21] There is however no fixed universe of removals, as sites needing removal actions are continually discovered. EPA estimates that on average there are 220 federal removal actions started each year, with an average of 180 removal actions completed per year.

Findings About Removals Sites

Removal data for eight sites were obtained from EPA's Removal Cost Management System (RCMS). The data came to RRA in automated form with records on labor category and hours worked. The sites were in four of EPA's ten regions. (See Table K.) Each EPA region uses the RCMS system to different degrees; some do not seem to use it often, while others fill out each field of information on a regular basis.

Labor Mix. Based on a detailed study of Removal Cost Management System data for eight removals in seven states in four EPA regions -- which represented an array of removal actions including four time critical and one non-time critical action, those that took two weeks to clean up and those that took eleven months to remediate -- overall labor mix, by number of hours worked, was: laborers 62 percent, equipment operators 35 percent, and drivers 3 percent. Other crafts -- represented in smaller amounts -- included field clerk/typists, chemist/organic, health and safety and truck supervisor, program manager, and secretary. (See Tables L and M.)

Duration of Cleanup. Removal actions, both federal and state, are restricted to either a time limit of one year for completion or a spending cap of $1 million. A new action memo may be written to get a dollar exemption or a time limit extension. A 1994 report[22] (which combines state and federal removal data) found that the average duration, for removal-only sites that reported start and completion dates, is 13.89 months (which exceeds the 12 month legally-mandated time limit). On average, completed state and federal removal-only sites have cleanup cost of $3.8 million.

2. Sites Regulated by EPA's RCRA Program

Background on RCRA

EPA, through the Resource Conservation and Recovery Act (RCRA), has developed a basic framework for regulating waste generators, waste transporters, and waste management facilities. RCRA began as an amendment to the Solid Waste Disposal Act in 1965, was passed as a law in 1976, and was amended in 1980 and 1984. The Act provides a regulatory framework for the nation's management of hazardous and solid wastes. Sites covered by RCRA are the largest and most expensive part of the overall environmental remediation budget. RCRA sites include landfills, waste piles, surface impoundments, land treatment units, tanks, tank areas, containment areas, and satellite accumulation areas. RCRA is divided into four programs: underground storage, medical waste, non-hazardous solid waste, and hazardous solid waste. There are a wide variety of wastes located on these sites, the scope of which resembles that of the Superfund universe.

Corrective action site cleanups are funded by site owners or operators. There is no funding program like Superfund to cover sites in the RCRA corrective action universe. The releases from solid waste management units (SWMUs) at treatment, storage and disposal facilities (TSDFs) are included in those remediations covered by the RCRA corrective action program. EPA defines a SWMU as "any discernable unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include areas at a facility at which solid wastes have been routinely and systematically released."[23]

While RCRA sites were not the focus of this study, several of the sites studied in this report have ongoing RCRA activities -- Ciba-Geigy, Paducah, and Weldon Spring among them.

Findings About RCRA Sites

Total estimates for the number of TSDFs range from 4700 to 5100,[24] with between 1500 and 3500 of the regulated TSDFs requiring corrective action. Beyond this there are an estimated 21,575 large quantity generators; 190,431 small quantity generators; and 2,389 treatment, storage and disposal facilities acting as generators.[25]

RCRA sites are divided into Solid Waste Management Units. There are approximately 80,000 pre-existing SWMUs at TSDF facilities. Because of the various methods used to treat, store, incinerate, and dispose of many different types of hazardous wastes, operations of these facilities are often complex and costly.

By the end of FY92 corrective actions were underway or completed at 247 facilities, about 3,500 facilities had undergone RCRA facility assessments, and 614 were undergoing RCRA facility investigations. Of these RCRA sites approximately half use off-site disposal remedies and half use innovative treatment technologies. SVE, in-situ bioremediation, and above ground treatment (bioremediation) each make up about a third of the innovative technologies in use.

The workers at RCRA sites are often industrial workers employed by the facility that has a RCRA site to clean up. Collecting data on the labor mix at these cleanup sites is recommended for future research.

3. Department of Energy Environmental Restoration Sites

Background on DOE Sites

For more than 40 years the United States produced nuclear weapons and generated significant amounts of both radioactive and hazardous waste. In 1989, the Office of Environmental Restoration and Waste Management, now called the Office of Environmental Management, at the U.S. Department of Energy, was created to address issues of environmental contamination from DOE production sites.

The Office of Environmental Management has five major tasks, summarized below with an estimated total (75 year) budget of $230 billion:

- *Waste Management ($112 billion)*: To minimize, treat, store, and dispose of DOE waste and to protect worker safety, public health, and the environment. Responsible for hazardous waste, transuranic waste, spent nuclear fuel, sanitary waste, mixed low-level waste, low- level waste, and high-level waste.
- *Environmental Restoration ($65 billion)*: To ensure that risks to the environment and to human health and safety posed by inactive and surplus facilities are either eliminated or reduced to prescribed, acceptable levels. Responsible for landlord activities, assessment, remediation, decommissioning, and surveillance and maintenance.
- *Nuclear Material and Facility Stabilization ($22 billion)*: Responsible for landlord, stabilization, and surveillance and maintenance.
- *Technology Development ($12 billion).*
- *National Program Management and Planning ($19 billion)* .

DOE is responsible for cleaning up 110 major installations in 4,000 individually contaminated areas covering over 26,000 acres. There are currently 23 DOE sites on 16 installations listed on the NPL -- Oak Ridge, Paducah, and Weldon Spring among them.

Restoring the environment to safe conditions at nuclear waste sites is achieved through remedial actions and decontamination and decommissioning (D&D). Remedial actions involve cleaning up inactive sites. These actions address contaminated soil and groundwater, as well as sometimes addressing surface-water contamination, tanks, buildings, and structures at active or inactive sites. D&D involves keeping inactive buildings safe until they can be decontaminated, entombed, dismantled and removed, or converted to another use. These structures include reactors, hot cells, processing plants, storage tanks, and other structures. D&D will take place at approximately 500 facilities.

Some of the contaminants at DOE sites are unique to the DOE complex, with mixed waste, containing both radioactive and hazardous waste, constituting a problem at a number of facilities. Other contaminants closely resemble those found on Superfund sites.

Many DOE facilities have both active and inactive sites and therefore must meet the requirements of both RCRA and CERCLA. Thus, DOE and its federal and state regulators often have to coordinate cleanup activities and schedules that stem from the requirements of each Act. DOE's facilities in Oak Ridge, Tennessee are an example of the dual application of RCRA and CERCLA. At Oak Ridge, DOE started corrective action work under RCRA in 1988 on a storage site for solid waste (Waste Area Grouping 6). In 1989, WAG 6 also became subject to CERCLA's requirements when the Oak Ridge site was placed on the NPL. At some DOE facilities, sites regulated under RCRA must be remediated in conjunction with sites addressed under CERCLA. For example, Hanford's B-pond, a disposal site for liquid wastes, is being cleaned up under RCRA, while abandoned trenches that formerly brought wastes to the B-pond are being cleaned up under CERCLA.

Findings About DOE Sites

From the Certified Payrolls

Data from certified payrolls from six DOE sites were obtained by RRA for its labor market data base. These sites were: Durango, Grand Junction, and Rifle in Colorado; Paducah Gaseous Diffusion in Kentucky; Shiprock in New Mexico; and K-25 (Oak Ridge) in Tennessee.

Labor Mix. Labor mix at the six DOE sites in the RRA data base varied significantly, even among the four Uranium Mill Tailings Radiation Control Act (UMTRA) sites. (See Table N.) UMTRA sites, a gaseous diffusion plant, and a

former enriched uranium plant pose very different cleanup challenges and tasks, and account for real differences in labor mix.
While most sites predominantly used equipment operators, laborers, and truck drivers, a wide variety of other skilled craft labor, such as roofers, plumbers, and electricians were also used. At Grand Junction, there were a large number of railroad workers employed.

Wages. Average hourly earnings among crafts varied across the DOE sites studied. Plumbers/pipe fitters at Paducah earned an average of $23.00 per hour, while at K-25, they earned an average of $17.77 per hour. Laborers at Paducah earned, on average, $15.32 per hour; at K-25 they earned $12.36; and at Shiprock laborers earned an average of $10.80 per hour. (See Table O.)

Other Sites Studied

Other DOE sites for which interviews were conducted, but certified payrolls were not obtained included Weldon Spring in Missouri and the X-10 and Y-12 Plants on the Oak Ridge Reservation in Tennessee. Workers at Weldon Spring represented a broad array of crafts including carpenters, electricians, laborers, painters/sandblasters, plumbers/pipe fitters, and truck drivers. Tasks included bulk waste removal at the quarry and building removals. Data obtained through interviews at X-10 and Y-12 primarily provided data on industrial workers -- in these instances, chemical workers. Chemical workers at the Oak Ridge facilities earned between $15 and $17 per hour cleaning up mercury, remediating dormant reactors, and performing general D&D activities.

Decontamination and Dismantlement at DOE Sites

Across the DOE complex -- are buildings that, because of their level of contamination -- often radioactive contamination need to be specially treated and then demolished.

Decontamination technologies work at removing surface contamination. They include brushing, scraping, scrubbing, scabbing, vacuuming, pressurized steaming, strippable coating, water jets, shot blasting, grit blasting, pellet blasting, and chemical foams.

The dismantling of a building involves removing yard structures, sealing contaminated structures and working on surface decontamination. The dismantling process also involves the removal of asbestos materials, followed by removal of electrical equipment, piping, water lines, gas lines, tanks, heating, ventilation, etc. The last steps are usually the removal of air filtration apparatus and the removal of the roof, exterior walls, and internal structural members. After above-grade decontamination and dismantlement, foundations, slabs, and pads would be decontaminated or stabilized to minimize further soil contamination. These foundations would then be removed. Dismantled materials would go into interim storage or be transported off-site.

Estimates made at the Fernald Environmental Management Project for its Operable Unit 3 in May 1994[26] were that dismantling and decontamination (D&D) would take 16 years and cost $1.076 billion (in 1994 dollars), not including caretaker maintenance. The job would require 6 million person hours of work, not including on-going site O&M.[27] Of this total, 9 percent of the work would be to support interim storage activities; the remaining work would be for D&D.

Operating costs for decontaminating include crew costs, chemicals, electrical power and waste disposal. Crew costs include the labor for equipment set-up, decontamination, radwaste treatment, and waste packaging. Typical crews have a range of specific crafts, but generally include a machine or a tool operator and a laborer. Plumbers and pipe fitters are needed for D&D when removal of piping and tanks is needed. Carpenters, electricians, and other crafts are utilized on a less consistent basis for other D&D associated tasks.

Uranium Mill Tailing Remedial Actions Sites (UMTRA)

The Department of Energy in 1978 was directed by Congress to remediate sandlike tailings from mineral processing located at 24 designated sites and at approximately 5000 vicinity properties in ten states and on two Indian Tribal lands. Work was authorized by Public Law 95-604, the Uranium Mill Tailings Radiation Control Act of 1978. The Act directs

DOE to provide for stabilization and control of the tailings in a safe and environmentally sound manner. States pay 10 percent of remedial action costs and DOE pays the remaining 90 percent. On the Indian Land sites, the federal government pays 100 percent of the cleanup cost. The tailings were from uranium production of the 1950's, 1960's, and 1970's.[28] Work at the UMTRA sites requires the relocation of residual radioactive material to safe disposal sites for long-term stabilization and control. Eleven of the sites were able to dispose of tailings on site. At Shiprock, the contamination was moved only 700 feet from the site, but in the case of Rifle, material was trucked 6 miles and for Grand Junction material was transported by truck and rail 18 miles. Site preparation includes fencing, and the building of temporary roads, drainage ditches, and wastewater retention basins. The next phase of work includes excavation, transportation, and placement and construction of necessary support facilities. Tailings are placed in an underground disposal cell, covered with earthen radon and frost protection layers, drain and filter layers, and a rock erosion protection layer. Surface runoff diversion ditches are usually constructed. Any on-site buildings would likely require decontamination. The site then requires grading and landscaping. DOE has set 1998 as a goal for completing the surface work and 2014 for completing the groundwater components of the project.

The 24 sites are divided into high, medium, and low priority. The four sites for which certified payrolls were obtained are high priority sites: Durango, Grand Junction, and Rifle in Colorado and Shiprock in New Mexico. The four sites compose 33 percent of the volume of contaminated materials at all UMTRA sites (13,000 of 39,000 thousand cubic yards), 18 percent of the acres of contaminated land (700 of 3900 acres), and 88 percent of the vicinity properties (4600 of 5300 properties).[29]

Findings: UMTRA. Four of the six DOE sites for which certified payrolls were obtained were Uranium Mill Tailings Remedial Action sites. These four sites were: Durango, Grand Junction, and Rifle in Colorado and Shiprock in New Mexico.

UMTRA Labor Mix. Certified payroll data, from four UMTRA sites in Colorado and New Mexico, were reviewed. Actual labor mix varied from site to site. The share of gross pay for operators ranged from 8 percent to 64 percent. Drivers made up 11 percent to 42 percent of payroll. Laborers made up as little as 3 percent and as much as 23 percent of gross pay. (See Table P.) At Grand Junction a large share of the off-site transport was by rail.

While the predominant crafts at UMTRA sites are clearly operators, drivers, and laborers, a number of other crafts were represented as well -- mechanics, carpenters, electricians, cement masons, concrete masons, flaggers, iron workers, pump men, surveyors, trainmen, track washers, welders, working foremen, timekeepers, security personnel, engineers, project managers, superintendents, and clerks. Across the four UMTRA sites, operators accounted for 38 percent of the payroll, drivers 28 percent, and laborers for 17 percent of the payroll. (See Table Q.)

UMTRA Wages. The four UMTRA sites studied had average hourly earnings of $14.94 (including overtime, shift differential, hazard pay, etc). (See Table R.) Site averages ranged from $12.66 at Grand Junction to $15.67 at Durango. The other sites had average hourly rates of $12.82 (Shiprock) and $15.18 (Rifle). Craft averages, across the four sites, ranged from $13.01 for laborers to $20.78 for electricians.

Where UMTRA Workers Live. Significant payroll at three sites was earned by workers residing in the towns of the sites themselves (Data were available for Grand Junction, Rifle, and Shiprock). At least 35 to 47 percent of gross payroll at each of the three sites went to those living in the same cities where the cleanup sites were located. Of all the hazardous waste sites surveyed as part of this study, the UMTRA sites seemed to rely the most heavily on local labor to get the cleanup done. For Rifle, a town of only 4,600 people, nearly $2.5 million in payroll went into the town -- and this, of course, did not include money spent by other workers while in Rifle, as well as money received by businesses for supplies and equipment, etc. In Shiprock, a town of less than 7,700 individuals, where approximately 46 percent of the workforce resided, over half a million dollars in cleanup monies went directly to the community, and many learned new skills as well. Towns affected by a hazardous waste site at least received some of the financial benefits of cleanup through wages for residents and purchases from local merchants.

The definition of local community can vary from site to site. The Shiprock UMTRA site, located on the Navajo Nation, reported over 98 percent of gross pay on its certified payrolls earned by individuals who lived within the Navajo Nation.

Though nearly half of that gross pay went to those who lived within the town of Shiprock itself, other Navajos traveled many miles a day to work. Nonetheless, the Navajo Nation, as a community, earned nearly the entire payroll.

4. Department of Defense: Defense Environmental Restoration Program

Background on DOD Sites

Measured by number of contaminated sites, the U.S. military is the nation's largest polluter -- having nearly 12,000 sites at 760 military bases in need of cleanup.[30] In addition, the Department of Defense (DOD) is responsible for the cleanup of more than 3,000 sites at 2,200 former domestic bases, many of which contain buried waste. There are 122 DOD sites and 19 former defense properties on the NPL. There are 81 installations with anticipated cleanup bills exceeding $100 million. (Fifty-seven of the 81 DOD facilities whose cleanup is expected to cost more than $100 million are on the NPL.)

DOD has released into the environment the same types of pollution found at privately owned industrial facilities: paints, petroleum products, solvents, and heavy metals. Some facilities have PCB contamination from electrical equipment. Some sites have minor radiation problems, such as radium dials from old aircraft, but the majority of significant radiation problems have been physically transported to Department of Energy sites such as Hanford and the Idaho National Engineering Laboratories.

The most common types of contamination found at DOD sites are landfills, spills, and surface impoundments. Surface discharge areas -- including spills, lagoons and disposal areas -- account for 24 percent of the contamination at active domestic sites. Storage tanks, primarily leaking underground tanks, account for 18 percent of the contamination.[31] Groundwater is contaminated at 80 percent of the sites.[32]

The Deputy Assistant Secretary for Defense has oversight responsibility for the Defense Environmental Restoration Program (DERP), with the Army, Navy, and Air Force responsible for program implementation only. The two major components of DERP are the Installation Restoration Program (IRP), and Other Hazardous Waste Operations (OHW). IRP is responsible for cleanup; OHW is responsible for preventing continued pollution and managing hazardous waste through research, development and demonstration of technologies.[33]

The Department of Defense's IRP has four phases similar to the phases involved in other cleanup programs:[34]

- Installation assessment, which includes site inspection, record searches, identifies bases with closed, potentially hazardous waste sites.
- Existence of contaminants affecting environment are confirmed.
- Teach developed or advanced methods to solve problems if necessary.
- Remedial action designed and executed.

Findings About DOD Sites

Findings from Sacramento Army Depot indicate continued heavy use of laborers (who earned 45 percent of gross pay) and operators (who earned 40 percent of gross pay). Other crafts at the site included electricians (1 percent of gross pay) and asbestos workers, drillers, and drivers who each earned less than 1 percent each of the gross pay. Sacramento Army Depot had a higher than average use of overtime as a percent of total hours (18 percent). The average hourly rate at Sacramento Army Depot was the second highest in the RRA data base at $23.85.

Data received from Concord Naval Weapons Station through a site visit and correspondence indicated that rates of pay for laborers and operators were about $30 per hour. Unfortunately, the RRA data base does not contain enough data from DOD sites to make any concrete generalizations. Interviews conducted with personnel involved in remediation activities at Concord Naval Weapons Station, McClellan Air Force Base, Hunter's Point Naval Shipyard, and Pillar Point Air Force Base, did not contradict earlier findings. One explanation of higher than average earnings could be that each of these sites is located in California. Data from these sites were used to strengthen projections on containment, USTs, and excavation remedies.

5. Underground Storage Tanks

Background on UST Sites

There are millions of underground storage tanks (USTs)[35] across the United States. USTs -- which store gasoline, crude oil, and hazardous substances -- are managed by RCRA Subtitle I. If they contain hazardous waste they are regulated under Subtitle C of RCRA. Over 1.6 million underground storage tanks are subject to federal regulation, with about 91 percent containing petroleum products and approximately two percent containing hazardous material.[36]

Landfilling technologies comprise over half of the technologies selected to treat petroleum contaminated soils from USTs -- followed by in-situ treatment, thermal treatment, and bioremediation. About 40 percent of all UST cleanups involve innovative technologies -- most commonly soil vapor extraction, in-situ bioremediation, and thermal desorption. Technologies currently being used to manage petroleum contaminated soils at USTs are divided into three categories: ex-situ management, in-situ management, and groundwater management. In-situ technologies used are soil vapor extraction and bioremediation -- primarily for the management of groundwater, free product recovery, and pump and treat. Ex-situ technologies are used for low temperature, thermal strippers; hot and cold mix asphalt plants; for landfilling; for land treatment; and for stabilization and solidification.

Findings About UST Sites

Labor Mix

There are many descriptions of the work process for UST removal and remediation. The job usually requires the skills of laborers, equipment operators, and truck drivers. A composite of these skills may be combined into the work of an individual. The mix may change based on whether remediation requires removal or closure, the size and number of tanks, whether the tank is covered with earth or cement, etc.

According to a 1994 study,[37] the costs to a contractor of removing 18 USTs from a west coast military base (and closing five more in place) was $1,376,000 million, or, on average for removal only, $76,444 per tank. Of this total, 29 percent of the removal of tanks, piping, and off-site treatment and disposal was spent on labor.[38] The removal task itself was estimated to take 282.5 days[39] -- with 32 percent of the time for a site manager, 32 percent for an equipment operator, 32 percent for a laborer, and 4 percent for other workers. The off-site treatment and disposal was expected to utilize laborers and drivers, and perhaps operators as well.[40]

Timing of Cleanup

Tens of thousands of underground storage tanks have been removed or closed, and cleanup of the sites completed. In FY92 alone, almost 29,000 UST cleanups were completed. From September 1994 through September 1995, the cleanup of over 40,000 USTs was completed. But, there appear to be significant differences across the country as to the ratio of completions to active tanks. Across the country there is an average of 12 percent completions from the universe of active tanks. It is as high as 16 percent in Region VIII and as low as 8 percent in Region VI and 5 percent in Indian lands. The rate of cleanup seems unrelated to the total number of tanks, as the most significant in-roads in UST cleanup seem to be in Regions VIII and IV, the ones with the least number and highest number of active tanks, respectively.

6. State and Private Sites

Background on State and Private Sites

Only a small percentage of the nation's hazardous waste sites will be placed on the NPL. Cleanup of Non-NPL sites will require federal, state, local, and private actions. Some are federal facilities; most are being cleaned up under the jurisdiction of states and territories. The U.S. General Accounting Office has estimated that there are between 130,000 and 425,000 state sites that might need to be evaluated for possible cleanup action.[41] As a result of a report by EPA in conjunction with the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) with further work done by Kensington Systems, Inc.,[42] there were over 20,000 sites in a state/territory data base -- with thirty-nine states and two territories reporting.[43] It is difficult to bring all state sites into one data base for analytic purposes.

According to EPA, the differences in terminology and systems for tracking accomplishments by the States and Territories makes the "the development of conclusions a challenge."[44]

Additionally, because not many private site remediation efforts have been completed and because private sector cleanups are voluntary and there is no public source for keeping historical data, little detailed information exists on these sites. Compliance standards which strongly influence remediation costs vary from state to state, and may not always be enforced. Therefore, costs associated with these Non-NPL sites may be somewhat inconsistent across projects.[45]

During the 1990's, EPA commissioned Kensington Systems, Inc.[46] to develop a data system on State and Territory Environmental Restoration Activities. This led, in August 1994, to the "State and Territory System Documentation" data base. In all, data were collected for 22,902 sites, whose remediation work cost over $1.2 billion. Information collected included duration of projects, the cleanup costs for state and PRP sites, and predominant remedies used.

Findings About State and Private Sites

Review of the EPA/ASTSWMO data suggests the major focus of states in remedy choice is off-site containment, with 61 percent of reported sites choosing it as a predominant remedy. (See Table S.) In some states; e.g., South Dakota, Rhode Island, and Alabama, off-site containment was the major remedy at 90 to 100 percent of all reported sites. (See Table T.) A few states focused equally on other remedies, with, for example, 100 percent of California sites (in the ASTSWM0 data base) choosing site security as major remedy and 76 percent of sites in Kansas using on-site treatment. The major crafts in demand were, therefore, most likely laborers, operators, and truck drivers and/or railroad personnel. Most actions took less than a year and cost between $300,000 and $400,000.[47] Among 4,000 predominant remedies across 31 sites in the data base, containment methods accounted for 76 percent of all predominant remedies, with 80 percent of the containments being off-site. (See Table S.)

Duration of Activities. A majority of state response actions reported in the EPA/ASTSWMO/ Kensington data base took less than a year to complete. At least half the response actions for 19 of 27 states reporting on duration were of less than a year's duration. (See Table U.) For five states, 80 percent or more of response actions lasted less than a year.

There were sites, however, where cleanup lasted three years or more -- nine percent of the total number of sites for which duration was reported (562 of 5,904 sites). Over half of these "long-term" sites (306) were in New Jersey. Another 136 were in Illinois, Massachusetts and South Dakota. Thus, just four states accounted for nearly 80 percent of all the sites where cleanup lasted for three years or more. Nine of the 27 states reporting on duration had no sites at all with remediation lasting three or more years.

Duration varied considerably from site to site and from state to state. While two states, Colorado and Texas, had no actions lasting more than one year, in Florida 25 percent of the sites reported activities lasting more than 5 years. The data base, reporting on 22,902 sites, contains only 3,527 removal completions and 2,428 remedial action completions through 1992. (See Table V.)

Predominant Remedies By Site. The predominant remedy at 76 percent of the State/Territory sites was containment -- 61 percent off-site and 15 percent on-site.[48] At federal sites, a broader array of remedies were used. At Federal sites, for both remedial actions and removals, 84 percent (2248 sites) used four predominant remedies: on-site containment, 24 percent; site security, 22 percent; off-site containment, 21 percent; off-site treatment, 17 percent.

Remedy data in the EPA/ASTSWMO/Kensington study were reported for 15,990 sites in 31 states. Predominant remedies were divided into seven major categories:

- On-Site Treatment
- On-Site Containment
- Off-Site Treatment
- Off-Site Containment
- Population Protection
- Site Security

- Innovative Technology

In turn, each major category of predominant remedy was subdivided, so that, for example, on-site treatment is divided into 14 subcategories ranging from soil aeration to air stripping, from pump and treat to biodegradation. All together 36 categories of remedies are delineated in the data base. (See Table W and Appendix VII for remedy descriptions.) The data on predominant remedies are somewhat difficult to interpret because there is no available information on how many predominant remedies there might have been at a single site.

Sixty percent of on-site containment involved surface capping, rarely with a slurry wall. The next two most frequently used on-site containment techniques were surface drainage control and soil cover. Sixty percent of off-site containment involved excavation and final removal to an off-site landfill.

At seventeen percent of all state sites, treatment, either on-site or off-site, was a predominant remedy. Five remedies accounted for 80 percent of on-site treatments: pump and treat with off-site discharge, pump and treat with on-site disposal, air stripping technologies, soil aeration technologies, and biodegradation (in that order of usage). Incineration, pH neutralization, component separation, leachate treatment, and thermal treatment were less frequently used on-site treatment remedies. (See Table W .)

OTHER ISSUES

CHOICE OF REMEDY

Labor Market Demand By Type of Remedy

Clearly, the labor mix at a hazardous waste site is significantly affected by the remedy chosen. The first major choice is between containment and treatment.[49] Containment usually focuses on the skills of laborers, operators, and truck drivers; while treatment remedies are more likely to require a broader involvement of other crafts as well. The operations and maintenance phase of treatment cleanup is likely to require a range of industrial workers and machine operators.

Treatment rather than containment is the mandated remedy of choice at Superfund sites, according to the 1986 SARA Amendments. Following the passage of that legislation, the percent of source control RODS with a treatment remedy, for Superfund remedial actions, rose from 51 percent in FY87 to 84 percent in FY90. But the trend has reversed since FY90, with the percent of RODS with a treatment remedy falling each year -- and the FY94 percent falling to 57 percent.[50] The reason for this fall? Many blame the uncertainty of Federal regulations for the unwillingness of the private sector to take a risk with innovative efforts.

Still, many innovative treatment technologies are being developed. For soil treatment, these include: bioremediation, dechlorination, vitrification, soil vapor extraction, and thermal desorption. For groundwater technologies, these include, air sparging, bioremediation, and surfactant flushing.[51]

At state remediation and removal sites the major remedy chosen has been containment, mostly off-site. To the degree that decisions and responsibility move toward the state, pre-SARA labor mixes and state site remedies are more likely -- with a probable return in national focus to containment rather than treatment.

Remedy choices across the DOE complex vary considerably. Because there is significant groundwater contamination at many sites, there is a necessary focus at least at these sites, on treatment; e.g., at Hanford, Savannah River, Rocky Flats, and Oak Ridge. Operations and maintenance for pump and treat associated with groundwater extraction systems may require time frames as long as 100 years.[52] But at some DOE sites, the focus may be more on excavation and disposal, as at the Nevada Test Site or Idaho National Engineering Laboratory. Likely, there are combinations of remedy choices; e.g., at Fernald or Rocky Flats, where there is treatment and then off-site containment.

Because of the expense of transportation, excavation and disposal strategies are relatively costly. Incineration tends to be the most costly technology, but its performance is proven. Many in-situ technologies are relatively less expensive, but their applicability and effectiveness is less wide-spread. Unless a change in compliance standards or enforcement occurs, there will probably continue to be widespread use of proven, more expensive treatment options.[53]

The sites studied serve as an illustration of the diversity of crafts required for a task. For example, across the sites, carpenters, cement masons, electricians, iron workers, laborers, operators, painters, and plumbers and pipe fitters were all involved in the construction of decontamination pads. Well installation required the labor of carpenters, laborers, operators, and drillers.

Labor Mix With Containment Remedies

Labor mix varies with different containment remedies. Methods of containment include multilayered RCRA caps, soil caps, slurry walls, surface water diversion through grading and dike construction, solidification and stabilization and more. Also a factor in the labor mix is whether the final containment is on-site or off-site.

Some of these methods will require more diversity in the labor mix than others. For example surface water diversion through grading and dike construction is likely to be more diverse in the mix of crafts -- using pipe fitters, plumbers, perhaps cement masons, as well as laborers and operators, whereas excavation and off-site landfilling is likely to only require, laborers, operators, and drivers.

Landfills

The RRA data base contains certified payrolls and daily labor logs from four landfills -- Lipari and Lone Pine in New Jersey, Moyer Landfill in Pennsylvania and New Lyme Landfill in Ohio. All four landfill sites are on the NPL list. Lipari, Moyer, and New Lyme are Fund-lead sites, Lone Pine is a PRP-lead site.

Landfill Remedies. The presumptive remedy for landfills is containment because treatment of landfills is often impractical due to the size and/or the combination of contaminants within. Containment may be accomplished by capping, leachate collection and treatment, landfill gas treatment, and/or institutional controls.

Out of forty-four possible remedies for thirty landfills studied by EPA,[54] the multi-layer cap was considered, and passed through the feasibility study screening most often (eighty-nine percent). It was chosen as the remedy sixty-four percent of the time (more than any other technology). Some other alternatives considered were: clay caps, asphalt caps, concrete caps, synthetic caps, soil covers, chemical seals, and slurry walls. Clay capping passed screening fifty percent of the time, and was the selected remedy twenty-five percent of the time that it was considered. Twenty-eight of the technologies, including asphalt and concrete caps, never passed through the screening during the feasibility study.

The amount of money and number of hours involved in each of the four sites studied by RRA differed; nonetheless, the tasks at each were similar: line and cap the landfill so as to control contamination by hazardous materials. The technologies differed to some extent -- at Lone Pine a CLAYMAX cap was used, as was a carbon treatment system to treat groundwater/leachate both chemically and biologically. At Lipari a multilayer cap was used, as well as a batch flushing treatment system. Moyer used soil clay capping, and New Lyme used a RCRA cap, and used biological disc, sodium hydroxide precipitation, and granular activated carbon to treat the contaminated groundwater and eliminate leachate. However, overall remediation strategies -- capping the landfill and implementing groundwater/leachate collection systems -- did not differ substantially.

Landfill Jobs. There may be many categories of labor involved at each landfill site -- often more than a dozen. At Lipari a mixture of skilled crafts accounted for a significant amount of hours, while at Lone Pine laborers accounted for 34 percent of the person-days, with very few other crafts present. At Moyer, laborers, operators, and drivers accounted for 94 percent of the hours worked. At New Lyme, although many crafts were present, laborers, operators, and drivers together accounted for 70 percent of the hours worked.

The proportionate share of each of the major job categories differed from site to site. Laborers accounted for 18 percent of total hours at Lipari, 34 percent of person-days at Lone Pine, 50 percent of total hours at Moyer, and 21 percent of total hours at New Lyme. Operators accounted for 9 percent of work at Lipari, 23 percent at Lone Pine, 38 percent of total hours at Moyer, and 30 percent of total hours at New Lyme. The proportion of drivers to laborers to operators was approximately the same for three of the sites, but was much higher at New Lyme, where drivers had a much higher presence. The difference in overall percentages may be the result of the large number of other crafts working on a variety of tasks at Lipari, thus bringing down the overall percentage of labor attributed to drivers, laborers, and operators.

Why the differences? It is not clear the extent to which the job categories are defined differently at each site. The major difference probably has to do with the differences in the design of the plants. At Lipari the plant also operated as office space for O&M workers, while at Lone Pine the plant was designed as more of a raw structure. Thus, more finishing tasks were needed for the plant at Lipari, and more specialized craft workers were present. In addition, at Lipari a major sewer line was built, thus requiring a high percentage of plumbers and pipe fitters.

Landfill Pay. Davis-Bacon wage rates prevailed at all the landfill sites studied. Average hourly wages at Lipari ranged, among the predominant job categories, from $16.60 for laborers to $23.52 per hour for mechanics. At Moyer average hourly rates ranged from $17.57 for laborers to $21.20 for operators. Average hourly wages at New Lyme ranged from $11.00 for drillers to $20.53 for electricians. (See Table F.)

Excavation and Hauling

Excavation and/or hauling were the major activities at four California sites studied. Whereas one might have expected somewhat parallel staffing of these activities, such was not the case. Though all four sites -- a former battery plant, Embarcadero in San Francisco, Hunter's Point Naval Shipyard, and Pillar Point Air Force Station -- utilized the services of truck drivers, laborers, and operators; actual labor demand was affected by the following issues:

- If the hazardous material needed to be taken out of state, then rail was often involved and a number of additional laborers were needed to line rail cars. (For example, at Embarcadero and Hunter's Point.)
- If material was stockpiled at an intermediate point, awaiting its final destination, then additional operators were needed. (For example, at Embarcadero and Hunter's Point.)
- The number of truck drivers is highly dependent on the length of the haul and complexity of the truck.
- In some instances a scale operator may be needed. (For example, at Hunter's Point.)

In some instances there are additional tasks to be completed; e.g., screening excavated material and/or mixing it with something else (as at the former battery plant) or landscaping once the job is done (as at Pillar Point.)

EMERGENCY RESPONSE

Worker protection standards governing hazardous waste work include requirements pertaining to emergency response activities. However, the hazardous waste work employer has options with regard to how to respond to these emergency response requirements. A hazardous waste site cleanup contractor can employ an "emergency action plan" as the site emergency response program. In this instance, an emergency response system is applied to the site which involves recognition, issuance of an alarm, evacuation, and notification of an off-site emergency response organization; HAZMAT, fire and rescue, and/or emergency medical. On the other hand, that employer may organize, train, and utilize an on-site emergency response crew to deal with site emergencies. This is often referred to as a collateral duty emergency response team or, in the industrial setting, as a fire brigade.

"Emergency Action Plans" are the current choice for the majority of hazardous waste activities associated with removal, remediation, O&M, USTs, and like activities. In these cases, employers, in compliance with OSHA/EPA standards, coordinate emergency response activities with off-site response organizations; the local community emergency response organization is called in when an emergency situation develops. In this case, site workers may still need to be trained as first responders who may recognize the incident and need to report it.

RCRA/TSD sites far more frequently utilize collateral duty emergency response teams. In these cases, currently employed workers will be required to take additional hazardous waste training, in accordance with the OSHA/EPA regulations governing emergency response and the training of such responders. The actual number of workers engaged in emergency response in these instances will parallel the increased numbers of workers engaged in RCRA-TSD corrective actions. That is, where collateral duty emergency responders are utilized, there will be an increase in emergency response training demand. For those RCRA-TSD corrective action sites who develop "emergency action plans" the local community emergency response organization would be utilized as discussed previously.[55]

The demand for emergency response clearly increases as the volume of hazardous waste work increases. Additional on-site staff may be needed at hazardous waste locations. Additional burdens are also placed on existing emergency response personnel -- most often fire, police, and emergency medical employees of the public sector. The supply of emergency responders in the public sector is relatively inelastic, so an increase in HAZMAT incidents is likely to cause a parallel increase in the use of overtime.[56]

Findings on Emergency Response from Data Studied

Analysis of data from five data bases in three states (Arizona, California, and New Jersey)[57] documented the thousands of reported hazardous materials incidents that occur each year across the United States. Each reported data somewhat differently. While the level of under reporting and early reporting may significantly understate the number and severity of incidents, at least seven important facts do emerge:

- Transportation corridors are the location of a significant number of hazardous materials incidents. In Arizona, 48 percent of incidents were along transportation corridors;[58] in California, 33-37 percent of incidents were on ground transportation routes and involved "transportation" property.
- Emergency responders as well as facility workers and community residents are at significant risk of injury and fatality in the event of a hazardous release. In California in 1990 and 1991, emergency responders accounted for 12-15 percent of those injured. The AHMIR reports showed that of those exposed to an incident, responders were 32 percent of those contaminated and 5 percent of those injured.
- HAZMAT emergencies are often not contained quickly. In New Jersey, for example, of 2000 reported incidents over a nine-month period, only 23 percent had been contained at the time of reporting.
- There were injuries at five percent of the reported incidents in New Jersey. Fatalities were reported for one tenth of 1 percent of incidents. In California, both in 1990 and 1991, there was an injury/incident ratio of just over 0.2 (700 injuries in 3300 incidents in 1991 for example). Fatality/incident ratios in 1990 and 1991 were 0.001. In Arizona the ratio of injuries to incidents was 0.15-0.33 and the ratio of fatalities to incidents was 0.005 to 0.014, depending on the data base studied. The ratio of exposures to incidents reported in fire department records in Arizona was 0.76.
- Public sector emergency responders were not always present at incidents. While in New Jersey, fire services responded to 77 percent of the incidents and police also responded to 77 percent of the incidents; for 18 percent of the incidents neither fire nor police were on the scene when the incident was reported to DEPE (the state environmental protection agency).
- For 4 percent of the New Jersey incidents, evacuations of the public were required.
- Improvement in response time is needed. The U.S. Environmental Protection Agency considers response times less than 15 minutes as "timely." Statistics from the Arizona Fire Department for response time in 1993 showed average response time of 19 minutes though the median response time was 10 minutes. For forty-eight percent of the incidents the response time was more than 15 minutes -- with response times ranging from 0 to 91 minutes in all but one instance, when the response time was 254 minutes.

Findings on Emergency Response from the Literature

Hazardous materials incidents in 1993 and 1994, as studied by ATSDR in nine states,[59] were responsible for 11 fatalities, 1446 injuries, 457 mass evacuations, and 3125 episodes of accidental release. These HAZMAT incidents occurred in commercial/industrial areas over 60 percent of the time. One-fourth of the incidents occurred during transportation. Most frequently released were industrial chemical gases, herbicides, and acids. Two-thirds of the time injuries were to workers, with nearly 20 percent affecting residents and 14 percent affecting emergency crews.

Additional Issues

Where clean up and related activities occur at DOE sites, there may be special additional emergency response requirements associated with those wastes present at nuclear facilities. In these instances, additional emergency response planning, preparedness and response actions will be governed by NRC, FEMA, DOE, and perhaps others. If these special nuclear waste activities increase, one might expect an increase in the need for emergency response personnel and training, although the dimensions of such an increase may be small and difficult to qualify.

There are some nine Federal Agency standards requirements for emergency response activities. Recently, the "ONE PLAN," the National Response Team's Integrated Contingency Plan Guidance was published in the Federal Register (61FR 28641). This Plan provides guidelines which, if followed, would achieve compliance with all current Federal emergency response requirements.

The hazardous waste worker protection standards by OSHA and EPA are the only agencies whose standards apply to less-than-full-time emergency responders; i.e., volunteers. To the extent that hazardous waste clean-up activities are conducted in places where the emergency response needs are met by volunteer emergency response organizations, special attention to the training and equipment needs of those volunteer departments will continue to be needed.[60]

Demand for Labor: Emergency Response

An analysis done for the Occupational Safety and Health Administration, estimated that there were 28,000 local fire departments, 22,000 industrial in-plant emergency response teams, 750 commercial (private) hazardous material response teams, and 200 public hazardous material response teams.[61]

The average number of workers assumed to be involved in response was 10 for local fire departments, commercial response teams and public response teams and eight for in-plant response teams.[62] Data from two surveys reviewed by an OSHA contractor found that the ratio of fire brigade members to total employees in manufacturing was approximately 45:1.

Staffing needed for a HAZMAT team includes at least 2 entry staff, 2 backups, and 1 safety officer. In addition, emergency medical people must be on standby within a certain amount of reaction time to the incident.

When using self contained breathing apparatus, there must be a minimum of two people inside and two outside. The two inside must be trained to technician level, the two outside must be trained to operations level. Also, one of those on the outside will serve in a dual role; also functioning as incident commander. The incident commander decides who else to call in. Most often it is a snowball effect, with one agency calling another, and so on, until there is sufficient response.

Emergency Response at Nuclear Facilities Has Additional Requirements and Notification Procedures

There are four levels of Emergency Response at facilities for which the Nuclear Regulatory Commission has oversight:

1. Unusual Event: No release of radioactive material
2. Alert: Minor incident
3. Site Area Emergency: Release that is within the boundary of the facility
4. General Emergency: Release that is beyond the boundary of the plant

The emergency planning zone is a 10 mile radius of the facility. At Perry Nuclear Power Plant in Ohio, this includes three counties, with one taking on the role of Emergency Operations Center.[63] They train, out of three counties, 3500 - 4000 people a year. This involves, one to four hour emergency responder training, with more time if necessary. Those trained include school bus drivers. (who get two to three hours of training).

Every two years there is a disaster drill, evaluated by the Nuclear Regulatory Commission and the Federal Emergency Management Agency.

ENVIRONMENTAL JUSTICE AND ECONOMIC OPPORTUNITY

Many hazardous waste sites are located in close proximity to low-income communities made up of African-Americans, Hispanics, Native Americans, and other people of color. While there is not full agreement on the reason for this inverse relationship between race, economic status and environmental quality, there is general agreement about the need to accelerate the process of hazardous waste clean up, especially in underprivileged communities from which departure is constrained by economic reality.[64]

The data derived from this study help to identify where hazardous waste workers live. Some believe that one important part of the environmental justice equation is that those whose communities have been most negatively affected should have the largest possible opportunity to gain employment in the cleanup.

At an individual community level, the infusion of thousands, even millions, of dollars allows for the growth of local economic base when those dollars stay within a community -- creating potentially important sources of funds for both the HAZMAT worker and for those from whom these workers purchase.

In many instances local individuals form a large segment of a cleanup work force. At the Shiprock UMTRA site, located on the Navajo Nation, for example, over 98 percent of the gross pay from certified payrolls was earned by workers who lived within the Navajo Nation. (See Table 2 for Shiprock.) Nearly 50 percent of the total was earned by those who lived within the town of Shiprock itself. Thus, individuals in a town of less than 7700 people earned over half a million dollars in the cleanup of their community, and many learned new skills as well.

A more detailed review of the communities in which workers reside was done for Lipari Landfill. In the communities where Lipari workers resided, Lipari workers were among the higher wage earners. Though census data is in medians and certified payroll data is in averages, the trends are still clear. As the percent of non-white residents in communities surrounding Lipari goes up, median hourly income generally goes down. (See Chart 2.) Regardless of racial composition, average hourly wages at Lipari were consistently higher than earnings throughout the community. The wages earned by Lipari workers did not alter significantly with racial make-up of communities where workers resided.

Workers at Lipari provided above average earnings across many New Jersey communities. While many New Jersey residents living in relative proximity to Lipari gained employment, one town just adjacent to the site, Glassboro, with an unemployment rate over 10 percent, received only $15,000 in pay from a studied payroll of over $4 million. Conscious efforts to include community residents in the work force at Lipari might have altered that.

There seems, however, to be no pattern in the level of skills and racial composition of workers within a community; i.e., workers from communities that were more largely non-white were as likely to provide iron workers and operating engineers as general laborers and truck drivers.[65]

(Chart 2, "Lipari Landfill" is available upon request)

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Section III:
DEMAND FOR JOBS OVER TIME

The demand for workers to clean up hazardous waste is very large -- through the year 2010, well over five billions hours of work will be required. The jobs are in every state and span job skills of the construction, industrial, transportation, and emergency response work forces. Any predictions of the future require that assumptions be made about the future. Assumptions made in this section of the study are discussed below, as are outside sources and the methodology used. Projections are based on real experience at hazardous waste sites over the past decade or more. The detailed experience-based approach of this study provides perspective, depth and credibility to the projections made. Using the same data, other researchers might use different assumptions that could result in other arrays of projections.

A. PROJECTIONS OF THE OVERALL NUMBER OF WORKERS NEEDED TO COMPLETE MANDATED HAZMAT CLEANUP

The RRA data base provides experience-based information on average hourly earnings and craft mixes at remediation sites. Using these data, along with data from an extensive literature review on the cost of remediation activities, projections were made on the number of jobs generated by hazardous waste cleanup work. The process described in this chapter yields an overall demand of 3.4 million job years, with approximately 5.4 billion hours worked on-site by remediation workers.

In addition to these direct on-site jobs, many others will be employed to complete a wide variety of tasks:

- Other craft labor jobs are generated in phases other than remedial action; e.g., well drilling during site investigation;
- Other craft jobs exist for ex-situ treatment and containment or for transportation of hazardous waste off-site;
- Many more direct jobs are generated for engineers, scientists, laboratory technicians, field technicians, and government officials throughout

the cleanup process;
- Jobs are also generated for a wide array of other tasks -- from suppliers of utilities, to manufacturers of equipment and parts, as well as through a general multiplier effect in the economy.

Issues Involved in Making Projections

Assumptions. There are many assumptions that affect projections. The RRA data base describes labor mix and wages from an array of completed hazardous waste site tasks. To make projections from the RRA data base, a number of assumptions had to be made.

- Number of Sites. New hazardous waste sites may be found. Criteria for listing sites may change and some sites, once on a cleanup list, may be dropped. As this number changes, the number of jobs needed to complete cleanup will change.
- Amount of Contamination. Sometimes the true extent of contamination is unknown until work has begun. When earth moving begins, there may be new discoveries that change estimates of the types and/or volume of contaminants. Researchers in one study[66] found that the volume of contaminated soil at 56 percent of the sites studied had been underestimated. This led to a 43.5 percent overall increase in the volume of soil which needed remediation.
- Choice of Remedy and Technology. The choice of remedy and specific technology used at a site clearly influences the cost of cleanup and potentially influences the labor mix as well. Containment is likely to cost much less than using an innovative technology to treat contaminated soil.
- Duration of Cleanup. Although one would expect the length of cleanup action to influence the cost with longer cleanups costing more money, this is not always the case. For example, when examining state removal sites no correlation was found between length of cleanup and cost. While one removal site took 57 months and cost $36,850 another removal took 7 months and cost $214,000. (See Table X.)
- Duration of Operations and Maintenance. The longer operations and maintenance activities continue the more expensive the site cleanup will be. Because O&M activities are just starting at some sites and have not yet begun at others, actual duration of O&M activities, as well as total costs are still uncertain.
- Choice of Equipment. The equipment used at hazardous waste sites clearly influences the labor intensity of work. At sites where hand tools are used significantly there are smaller units of earth moving at a time than when backhoes or bulldozers are used or when forklifts and cranes are added to a site. When contamination is close to a building, a more labor intensive effort may be necessary than when the contamination is in an open field because small tools may be needed to get close to foundations.

Models Used. Many models were reviewed as part of this study. These include the Work Force Breakdown Model, the Outyear Liability Model of EPA, Tracking System Models of several trade unions, the model framework of R.S. Means and others who make job site projections used in planning construction work. EPA studies on economic impact and multipliers associated with Superfund cleanup were also reviewed.

Use of the Word "Job". All calculations for jobs in this text are for a full-time job lasting one year. For construction labor, a full-time job-year is assumed to be 1500 hours of work. For operations and maintenance labor, a full-time job-year is assumed to be 2000 hours of work.

Discounting of Costs. Many studies which project the cost of hazardous waste cleanup discount those costs. Authors struggle to determine an appropriate discount rate to use, so that costs may be expressed in an accurate present value. In this study, only undiscounted costs are sought and used. This is because the research interest is not in present value, but rather in the actual dollars to be expended -- dollars which in turn reflect on the number of jobs being supported from those expenditures.

Sensitivity. A formal sensitivity analysis is not part of this report, but sensitivity analysis was performed throughout the research portion of the work. As additional sites were added incrementally to the data base, summary conclusions were not particularly sensitive. When assumptions were made for the purpose of making projections, the sensitivity associated with those assumptions was great, and this sensitivity is referred to throughout the text. Assumptions about cost of cleanup, the percent of cleanup costs accruing to remedial action and to construction labor, and the number of hours assumed to represent a full year of work, all have significant impact on the overall projections.

Uncertainty Associated With Making Projections. Making forecasts always involves uncertainty. Because this data base makes its projections from a diverse array of sites across the nation, based on actual work experience, many of the problems associated with extrapolating from one site -- and perhaps only the plans for cleaning up that site -- are eliminated. Nonetheless, the following issues are still obstacles to the challenge of making projections:

1 The degree of cleanup is dependent on the political process and policy choices, which affect budget, timing, research

into innovative technologies, designation of responsible parties, intensity of cleanup, etc. The cleanup of individual sites is under the jurisdiction of varying regulatory bodies, each with different mandates and cleanup requirements.

2. There are fundamental philosophical/political issues to be resolved. There is a major question of whether cleanup should be to resolve imminent danger (at a relatively low cost) or whether future generations should be protected, and hence more expensive groundwater or soil treatment should be used. To the degree that decisions and responsibility move toward the state, pre-SARA labor mixes and state site remedies are more likely; i.e., more containment and less treatment, and most of the containment will be off-site.

3. The diversity among state programs is great. Different states have different patterns of choosing remedies. Lying behind policy may be issues as diverse as unfunded mandate concerns, avoiding future liabilities, restoring land to productive use, avoiding the possibility of exposing workers or surrounding communities to risk.

4. To the extent that monies are expended on the front end to prevent pollution and find alternative ways to limit hazardous waste and dispose of it safely, waste management costs as well as the costs of cleanup will be diminished.

5. As the environmental remediation industry pursues R&D associated with more effective and more cost-efficient and innovative remediation technologies, the types of work tasks required may change.

6. Data are incomplete and inconsistent. Estimates have largely been for federal costs alone, with nonfederal costs excluded.[67] When the U.S. General Accounting Office surveyed federal agencies to see how far along they were in estimating costs, they found that officials at most agencies were uncertain about critical aspects of cleanup, such as the nature and extent of contamination problems and type of cleanup strategies needed.[68] Hence, GAO decided that it was impossible to estimate either costs or labor market needs.

When necessary, this study relies on the findings of past research efforts. These findings are not always consistent and the process of making projections required choices. For instance, many of the projections of the total cost for environmental restoration and waste management at DOE sites are estimated at $230-240 billion, but the estimated cost of cleanup at Hanford alone is $240 billion or more.

Another problem with projections is making a sensible estimate of the number of sites requiring cleanup. EPA in 1994 estimated the cost per site of NPL site cleanup to be $30.7 million with a total cost of $42 billion. This suggests the cleanup of 1368 sites, but EPA's Assistant Administrator Elliott Laws, also in 1994, suggested in a response to Congress over 1700 sites and the EPA Inspector General in 1994 estimated 3000 sites. In 1994 the GAO was publishing the Congressional Budget Office's best estimate of 3300 NPL sites.

Projections for HazMat Jobs 1990-2010

The base for projections is the actual experience at hazardous waste sites, as documented through certified payrolls. From this data-based picture of several past and present job sites and the labor used, projections for future labor demands are made. But, in order to make those assumptions, other data and a series of assumptions are necessary.

An estimate of the number of sites that will require cleanup and a cost per site for the array of site types and locations -- based on type of contaminant, amount of contaminant, and technologies to be used is needed. This report, because the focus was the collection and analysis of certified payroll data, relies heavily on the cost estimates available through the responsible government agencies or made by consultants and contractors.

One needs to assume the number of labor hours that comprise a full-time work year -- a number that is usually significantly lower in construction than for industrial labor. One must also estimate the share of remediation dollars that go to construction payroll and the share that go to operations and maintenance. And, finally, one must estimate the time frame in which the cleanup dollars will be spent, by category of cleanup. Once these assumptions have been established, projections can be calculated.

For the purposes of this study, the following assumptions were made:

Estimates of the Number of Hours that Comprise a Full Time Equivalent (FTE) Job for a Construction Worker for a Year. In some parts of the country, a construction worker has little expectation of work for more than 1000 hours a year. A forty hour, 52 week a year job provides 2080 hours a year of work. Many in construction consider 1400, 1500, or 1600-1800 a reasonable benchmark for a full year of construction work. The Current Population Survey, for 1992 and 1993 found the average construction worker employed 1981 and 1994 hours per year, respectively. Projections in this report assume a 1500 hour per year work year -- a floor that gained acceptance among most building trades experts interviewed.

Estimates of the Share of Remediation Dollars That Go to Construction Payroll. Estimates of the share of remediation dollars that go to construction payroll at NPL and other hazardous waste sites is estimated to be 15 percent; based on the following assumptions and expert opinions:

> The RRA data base covers only portions of the total remediation jobs at the NPL sites studied. Table 4 uses the gross pay in the RRA data base, knowledge of work on the site, and total capital cost to estimate a benchmark for the percent that construction payroll is of total NPL remediation costs. Some experts estimate construction labor cost at 15 percent of remediation. Other expert opinions suggest 18 percent at hazardous waste sites and 25 to 33 percent for heavy construction more generally. To be conservative, 15 percent was used in projections. Clearly the numbers could nearly double if a heavy construction site proportion were used.

This report provides projections through the year 2010. However, each category of remediation -- Superfund, RCRA, DOE, DOD, Underground Storage Tank sites, and State and Private sites -- may require different time frames to reach completion of cleanup. These time frames are discussed in Section II.

Table 4

Labor Costs as a Percentage of Total Remediation Costs at 5 NPL Site

Site	Quoted capital cost in ROD	Other quotes[1]	Collected Gross Pay	% of Total Job in RRA Data Base	Labor Cost As % of Total Cost[2]
Lipari	$26,233,150	-	$4,052,419	80%	19%
Moyer	$6,298,500	$13,400,000	$1,142,272	75%	11%[3]
New Lyme	$10,798,000	$17,280,000	$2,789,360	80%	20%[4]
Bayou Bonfouca	$60,497,534	$115,000,000 [5]	$5,173,534	75%	9%[6]
Sacramento	$7,398,414	-	$201,887	15%	18%

Sources: Ruth Ruttenberg & Associates, Inc. Data Base, and Interviews with Contractors and Site Officials.

[1] Obtained through phone calls or written correspondence.
[2] Assuming that labor costs for the percent of work which was not captured are similar to those that we did.
[3] Based on $13,400,000 as total site remediation cost.
[4] Based on $17,280,000 as total site remediation cost.
[5] Present contract value as of 1/95.
[6] Based on $115,000,000 as total site remediation cost.

Projections for Nationwide Hazardous Waste Cleanup

The labor market projections in this study are based on the findings reported in Section II, along the cost estimates and assumptions found at the beginning of Chapter III. The individual category projections are explained in the pages that follow. For summary and overview purposes the full projections are presented first. (See Table 5 for "best" estimates and Table 6 for a reasonable upper bound.)

The 3.4 million expected job years of labor for cleanup yield an estimated 5.4 billion hours of work -- based on an estimated 2.9 million construction job years (1500 hours per job year) and 500,000 O&M job years (2000 hours per job year).

Table 5

Labor Market Projections for Remedial Action and O&M Jobs Based on University of Tennessee "Best Estimate"				
Category	UT "Best Estimate" (billion $s)	Remedial Action Jobs*	O&M Jobs**	Total Jobs
NPL	$151	528,174	98,478	626,652
RCRA	$234	928,370	152,609	1,080,979
DOE	$240	952,174	156,522	1,108,696
DOD	$30	119,022	19,565	138,587
UST	$67	265,815	43,696	309,511
State/Private	$30	119,022	19,565	138,587
TOTAL	$752	2,912,577	490,435	3,403,012

Source: University of Tennessee

* Remedial action is assumed to be 73 percent of the cleanup cost (based on April 25, 1995 Federal Register Notice, 60 FR, p. 20,330). Direct craft labor for remedial action is assumed to be 15 percent of remedial action costs. If no hourly earnings data were available, $18.40 (the average hourly earnings for all sites in RRA data base) was used, except for NPL, for which average hourly earnings for NPL sites in the RRA data base, $20.87 was used. A full-time equivalent (FTE) job for a year is assumed to be 1500 hours.
** For calculations, O&M activity is assumed to be 16 percent of the cleanup cost (based on DOE study). Direct craft labor is assumed to be 15 percent of O&M costs. Average hourly earnings are estimated to be $18.40 and a full-time job is assumed to be 2000 hours (2000 hours is used here instead of 1500 hours because employment for O&M work is more likely to be on a regular full-time basis over longer periods of time.)

Using different cost estimates, from a study done for DOE, the following projections were made:

Table 6

Labor Market Projections for Remedial Action and O&M Jobs Based on Department of Energy "High Cost Alternative"				
Site Category	DOE "High Cost Alternative"	Remedial Action Jobs*	O&M Jobs**	Total Jobs
NPL	$302	1,056,349	196,957	1,253,306
RCRA	$790	3,134,239	515,217	3,649,456
DOE	$247	979,946	161,087	1,141,033

DOD	$35	138,859	22,826	161,685
UST	$74	293,587	48,261	341,848
State/Private	$308	1,221,957	200,870	1,422,827
TOTAL	$1756	3,690,698	630,000	4,320,698

Source: Department of Energy, The Demand For Environmental Restoration Services, 1993.

* Remedial action is assumed to be 73 percent of the cleanup cost (based on April 25, 1995 Federal Register Notice, 60 FR, p. 20,330). Direct craft labor for remedial action is assumed to be 15 percent of remedial action costs. If no hourly earnings data were available, $18.40 (the average hourly earnings for all sites in RRA data base) was used, except for NPL, for which average hourly earnings for NPL sites in the RRA data base, $20.87 was used. A full-time equivalent (FTE) job for a year is assumed to be 1500 hours.
** For calculations, O&M activity is assumed to be 16 percent of the cleanup cost (based on DOE study). Direct craft labor is assumed to be 15 percent of O&M costs. Average hourly earnings are estimated to be $18.40 and a full-time job is assumed to be 2000 hours (2000 hours is used here instead of 1500 hours because employment for O&M work is more likely to be on a regular full-time basis over longer periods of time.)

Estimated Cost of Cleanup

There are many estimates on the cost of cleaning up the nation's hazardous waste sites. All are projections based in significant uncertainties. Thousands of sites have yet to be thoroughly characterized, and once cleanup actually begins, there may be many new discoveries of additional types or amounts of contaminants. Federal, state, and private budgets, as well as public policies, may change.

Despite wide ranges in cost estimates, analysts agree that the remediation of hazardous waste sites will cost many billions of dollars. According to a widely cited 1991 University of Tennessee study,[69] the total cost of cleaning up U.S. hazardous waste sites -- NPL, RCRA, DOE, DOD, UST, and others -- will be $752 billion. (See Table 7) According to a comprehensive DOE-sponsored study,[70] the total cost will be $983 billion. (See Table 8) These two studies are broadly viewed as the most comprehensive studies of costs across hazardous waste activities. Each makes estimates for the cost of cleaning up sites by sector of responsibility; i.e., NPL, RCRA, DOE, DOD, Underground Storage Tanks, and State/Private sites. No other comprehensive study reviewed by RRA included such detailed cost estimates.[71]

Table 7

Cost of Hazardous Waste Cleanup: University of Tennessee Estimates (Billion of Dollars)			
Remediation Authority	Plausible Lower Bound	**Best Estimate**	Plausible Upper Bound
NPL (Superfund)	$106	**$151**	$302
RCRA	$170	**$234**	$377
Underground Storage Tanks	$32	**$67**	*
Department of Defense	*	**$30**	*
Department of Energy	$110	**$240**	*
State/Private Programs	*	**$30**	*

TOTAL	$478	**$752**	$1,046

Source: University of Tennessee, Hazardous Waste Remediation: The Task Ahead, Waste Management Research and Education Institute, 1991
* Denotes circumstances where the estimate is not thought to differ from the Best Guess or where no basis for drawing a Plausible Lower Bound or Plausible Upper Bound exists.

Table 8

Cost of Hazardous Waste Cleanup: Department of Energy Estimates (Billions of 1992 Dollars)			
Site Category	Low Cost Alternative	**Base Case**	High Cost Alternative
NPL	$116	**$186**	$302
RCRA	$257	**$457**	$790
UST	$29	**$49**	$74
DOD	$20	**$25**	$35
DOE	$57	**$113**	$247
State/Private	$77	**$153**	$308
TOTAL	$556	**$983**	$1,756

Source: Department of Energy, The Demand For Environmental Restoration Services, 1993.

The estimated cost of cleanup for Superfund sites varies greatly -- with ranges in this study from $37 billion (Resources for the Future) to $352 billion (University of Tennessee). DOE estimates its cleanup costs at approximately $230 billion, even though estimates are that cleanup at the Hanford site alone will cost at least that much and maybe even as much as $500 billion, over 75 years.[72] Estimates on remediating DOD sites range between $25 billion (DOE) and $30 billion (University of Tennessee). UST site cleanup estimates range from $49 billion (DOE) to $67 billion (University of Tennessee). Other cleanups -- including state, private, and non-NPL -- are estimated to cost between $30 billion (UT) and $153 billion (DOE).

The UT and DOE studies each developed numbers in mutually exclusive categories. But, it is not always clear into which category a site falls. A site might, for example, be under the jurisdiction of DOE, be listed on the NPL and also be regulated by RCRA. In this case, DOE would be responsible for all costs incurred in the remediation; including those which are regulated under CERCLA and RCRA.[73] The categorization of sites also affects the numbers for each type of activity. Sometimes, for example, the line between environmental restoration and waste management at DOE is unclear; e.g., the classification of underground storage tanks at DOE's Paducah site are environmental restoration, but at the DOE Hanford site, the tank farm activities are classified as waste management.

Estimated Cost of Operations and Maintenance

Major types of O&M activities include pumping and treating groundwater and in-situ treatment of soils and groundwater. For groundwater remediation, operations and maintenance costs are of primary concern because pump and treat systems operate over long periods of time. One study[74] suggests that while costs for groundwater remedial action are generally based on a 30-year period for O&M expenses, that remedial time frames for groundwater are underestimated by at least a factor of three. Costs include such post-installation expenditures necessary to provide for the continued effectiveness of remedial action as labor and material costs, sampling and analytic fees, and administrative costs[75].

Because few cleanups have reached the O&M stage, many O&M costs are still uncertain. One major study estimated that for each site category -- NPL, DOE, DOD, RCRA, Non-NPL, and Underground Storage Tanks -- O&M cost equals approximately 16 percent of total remediation costs. For NPL sites, EPA has estimated O&M to be 18 percent of total costs incurred during cleanup of an NPL site.[76] For the purpose of this study O&M costs were more conservatively estimated to equal 16 percent of the total remediation cost.[77]

B. PROJECTIONS OF LABOR MARKET NEEDS BY CATEGORY OF CLEANUP SITE

For each of the six major categories of cleanup sites discussed above, separate projections were made -- based on data specific to that category. These projections are presented below for Superfund, RCRA, DOE, DOD, UST, and State/Private sites.

1. Total Estimated Job Generation From NPL Site Cleanup

Estimating job requirements for NPL site cleanup is based on a number of important data sources and research assumptions. (See first part of Section III.) Beyond data finds from certified payrolls, it is necessary to estimate the number of sites and the cost of cleanup. Assumptions about the number of hours that represent full time equivalent job, the percent of total cost represented by construction labor on O&M.

Estimates on the Number of NPL Sites

There are many estimates of the total number of hazardous waste sites that will obtain Superfund status and be remediated. The three estimates listed below provided a range based on important and responsible sources:

> 1. The Current Number of Sites. As of April 25, 1995, there were 1285 sites on the NPL list.[78] This number is used as a floor for the total number of sites to be cleaned up. It assumes, very conservatively, that no new sites will be added to the NPL.
>
> 2. Congressional Budget Office (CBO). The CBO in 1994[79] estimated that the most likely number of total NPL sites would be 3300, with a range of 2300 to 7800 sites.
>
> 3. Environmental Protection Agency. The EPA Inspector General in January 1994 estimated that 3000 of the 6467 sites in the agency's evaluation backlog in 1994 was a likely number of sites to eventually be added to the NPL.[80] Based on approximately 1300 sites on the NPL list at the time of the estimate, a total of 4300 NPL sites was used as another benchmark for projections.

All estimates need to be treated as just that -- estimates. The cost estimates used here include different arrays of numbers. Efforts have been made to use undiscounted numbers because it is actual dollars expended that aid in projected wages and jobs. Some are in terms of dollars of different years than others. The University of Tennessee and Department of Energy estimates are for 30 years (through 2020). The CBO estimates assume that cleanup lasts for more than 50 years. DOE is now using a 75 year time frame at its sites, just for remedial action completions.

Cost of Cleaning Up NPL sites

There are many estimates for the cost of Superfund cleanup. The ranges of costs reviewed in this study are from $37 billion to $352 billion. (See Table 9.) EPA's best estimate for the average cost per site is $30.7 million. (See Table 10.)

Averages, however, may be misleading. At non-Federal NPL sites, for example, a small number of sites consume the lion's share of total NPL capital expenditures -- with 16 percent of the operable units accounting for over 60 percent of all cleanup costs. The majority of projects (69 percent) have capital costs of less than $10 million and 38 percent have capital costs of less than $3 million.[81] Full cost estimates per site, made in 1995 by Resources for the Future (RFF)[82] ranged from $10.7 million for TNT processing sites to $1704 million for mining sites. The average cleanup cost for landfill sites, the most common type of NPL site, was estimated to be $23 million; leaking container sites $34 million, and radiological tailing sites $75 million. The RFF average cost for NPL cleanups is the lowest of those surveyed in this study, $29.1 million. (See Table 9.)

O&M costs vary by type of remedial technology, with ongoing pump and treat of groundwater being a common O&M activity. O&M functions, when required, may continue for several years and represent activities that are distinct from the cleanup effort. O&M costs depend on many factors including the type of contamination at the site, the different media that must be treated, and the remedial technology selected. One DOE study asserts that O&M costs are positively related to the size of the site when containment strategies are employed, but probably not related to site size when a treatment strategy is utilized.[83]

Table 9

Range of Estimates For Cost of Superfund Cleanup														
Cost Estimate Source	RFF-$29.1 million per site, 1285 sites.	UT-$50.3 million per site, 1285 sites	UT-Low	EPA $30.7 million per site, 3000 sites.	RFF-$29.1 million per site, 3300 sites.	CMA	DOE-LOW	RFF-$29.1 million per site, 4300 sites.	UT-best	UT-$50.3 million per site, 3300 sites.	DOE-best	UT-$50.3 million per site, 4300 sites.	DOE-high	Univ of TN-high
Estimate of Total NPL Cleanup Cost - billion $	$37	$65	$90	$92	$96	$100	$116	$125	$151	$166	$186	$216	$302	$352

Sources: University of Tennessee, Department of Energy, EPA, Chemical Manufacturers Association, Brookings Institution and Resources for the Future.

Table 10

Breakdown of NPL Costs by Function		
FUNCTION	AVERAGE COST BREAKDOWN	
RI/FS	$1.35 million	4%
Remedial Design	$1.26 million	4%
Remedial Action	$22.5 million	73%
Operations & Maintenance	$5.63 million	18%
TOTAL Average Cost Per NPL Site	$30.74 million	99%

Source: U.S. EPA, Office of Emergency and Remedial Response, Office of Program Management, Policy and Contracts Assessment Staff, Technical Report: Economic Impact of the Superfund Program: 1981-1992, Draft, Washington, DC, 1994.

This study, for cost estimating purposes, focuses on the University of Tennessee is best "estimate" of $151 billion -- a figure cited often in the literature and a low middle number among the cost estimates reviewed. In 1991, the University of Tennessee's Waste Management Research and Education Institute issued a series of six studies on hazardous waste cleanup addressing cleanup costs for the wide array of NPL sites, RCRA sites, DOE sites, DOD sites, underground storage tank sites, and state and private sector sites. The University of Tennessee study was chosen because only it and the DOE-sponsored study were comprehensive -- and of the two, the University of Tennessee was more conservative in its costs estimates. The University of Tennessee estimates are frequently referenced and a baseline for the continuing research by many groups, ranging from Resources for the Future to GAO.

EPA estimates that 73 percent of the costs at a given NPL site are for remedial action work -- work which most intensively involves construction labor. For the portion of total NPL cleanup costs that, on average, is allocated to each major function, see Table 10.

NPL Cost Estimates from the Literature. The literature provides many estimates for costs associated with cleanup of Superfund and other hazardous waste sites. Results from several of these studies have been used to create a range for determining a responsible, conservative cost estimate to use as the base for projecting the numbers of jobs generated at Superfund sites. Cost estimates from five major studies are the focus of estimates in this report:[84]

1. The University of Tennessee, in 1991, published a series of six reports on the cost of environmental remediation.[85] Its best guess estimate for the total cost of environmental remediation was $752 billion, with 20 percent, or $151 billion, of that cost being for remediation of NPL sites. High and low estimates for NPL cleanup were $352 billion and $90 billion, respectively.[86]

2. The Department of Energy, in 1993,[87] in a review of all U.S. cleanup costs, estimated that NPL resource requirements for its base case, would be $186 billion. A low cost alternative was $116 billion and a high cost alternative, $302 billion.

3. The Chemical Manufacturers Association, in 1988,[88] estimated the total cost of Superfund cleanup at $100 billion.

4. The Congressional Budget Office, in 1994,[89] assumed that in a base case of non-federal sites, there would be 4,500 non-federal Superfund sites to clean up, at an average cost of $24.7 million per site -- suggesting a total, undiscounted cost of $111.2 billion. If the ratio of non-federal to total sites were to remain in the same proportion as today (1126 to 1223[90]). If non-federal and federal sites cost the same to clean up, then total undiscounted cost would be $120.7 billion.

5. The Brookings Institution and Resources for the Future, in 1995,[91] published a study which estimated total site costs, per site, to be $29.1 million.

Projections of NPL Construction Labor Jobs

When using University of Tennessee's best estimate, over half a million job years are generated as a result of construction labor activities in remedial action. After reviewing sixteen different estimates of the cost of Superfund cleanup, and a number of other assumptions, projections for job generation were made (See Table 11.) ranging from a low of 130,000 to a higher of over 1.2 million.

Table 11

Projected NPL Construction Labor Job Years On 13 Estimates Of NPL Cleanup Costs (Over 30 years)				
Cost Estimate Source	Estimate of Total NPL Cleanup Cost in billion $s	Dollars spent on RA (billion ($s)	Dollars Spent on Construction Labor (billion $)	Remedial Action Job Years

UT	$352	$256.96	$38.5400	1,231,241
UT best	$151	$110.23	$16.5345	528,174
UT low	$90	$65.70	$9.8550	314,806
DOE-high	$302	$220.46	$33.0690	1,056,349
DOE-best	$186	$135.78	$20.3670	650,599
DOE-low	$116	$84.68	$12.7020	405,750
CMA	$100	$73.00	$10.9500	349,784
UT-$50.3/4300 sites	$216	$157.68	$23.6520	755,534
UT-$50.3m/3300 sites	$166	$121.18	$18.1770	580,642
UT-$50.3m/1285 sites	$65	$47.45	$7.1175	227,360
RFF-$29.1m/4300 sites	$125	$91.25	$13.6875	437,230
RFF-$29.1m/3300 sites	$96	$70.08	$10.5120	335,793
RFF-$29.1m/1285 sites	$37	$27.01	$4.0510	129,420
EPA-$30.74m/4300 sites	$132	$96.36	$14.4400	461,715
EPA-$30.74m/3300 sites	$101	$73.73	$11.0595	353,282
EPA-$30.74m/1285 sites	$40	$29.20	$4.3800	139,914

Sources: University of Tennessee, Department of Energy, Brookings Institution and Resources for the Future.
[*] Remedial action is assumed to be 73 percent of the cleanup cost (based on April 25, 1995 Federal Register Notice, 60 FR, P.20,330). Direct craft labor for remedial action is assumed to be 15 percent of remedial action costs. If no hourly earnings data were available, $20.87 (the average hourly earnings for all NPL sites in data base) was used. A full-time equivalent (FTE) remedial action job for a year is assumed to be 1500 hours.

The first seven estimates depend on projections for total cost of NPL cleanup -- three from a 1991 study by the University of Tennessee, three from a 1993 study for the Department of Energy, and one by the Chemical Manufacturers Association (CMA). Based on these seven estimates the number of full time construction labor jobs generated as a result of Superfund cleanup ranges from a low of 129,000 to a high of 1.2 million. A middle and still quite conservative range might be 500,000 to 600,000 building trades job years over a 30 year period.

The remaining nine estimates are based on two sources estimating the cleanup cost per site, each with further estimates based on the number of NPL sites to cleanup. Two cost-per-site estimates are a University Tennessee estimate of $50.3 million per site and a Brookings Institution and Resources for the Future estimate of $29.1 million per site.[92] The latest average cost per site comes from EPA's April 1995 release of the NPL which estimates the average cost per site at $30.74 million. The three estimates of total number of NPL sites to be remediated are: a very conservative estimate of 1285 based on the number of actual NPL sites in April 1995,[93] a 3300 estimate of the CBO,[94] and an EPA estimate of 4300 based on an addition of 3000 of the 6467 sites in the agency's evaluation backlog in 1994.[95] The CBO estimate of 3300 had a range of 2300 to 7800 sites. The high range was excluded so as to keep estimates conservative.

Using actual average hourly earnings for each craft from the RRA data base, rather than the average hourly rate for all Superfund sites in the data base, causes the variance of total number of remedial action jobs found in Tables 11 and 12.

Table 12

Projected NPL Remedial Action Job Years by Craft			
Craft	Percent Gross Pay Earned	Average Hourly Wage	Number of Remedial Action Job Years
Carpenter	5%	$22.35	24,660
Cement Mason	1%	$19.88	5,545
Driver	4%	$16.89	26,105
Electrician	5%	$21.76	25,329
Iron Worker	3%	$21.18	15,613
Laborer	19%	$16.79	124,739
Mechanic	3%	$17.34	19,071
Operator	31%	$23.63	144,610
Plumber/Pipe Fitter	6%	$21.35	30,978
Other Crafts	23%	$20.87	125,200
TOTAL	100%	-	541,850

Source: University of Tennessee and Ruth Ruttenberg & Associates, Inc. Data Base.

Projections of NPL Operations and Maintenance Jobs

An estimate for O&M costs as a percentage of total cost is from a 1993 study supported by DOE,[96] which estimated O&M costs across all sites, on average, at 16 percent of total cost. This 16 percent estimate is used for projections in this study.

Operations and maintenance costs associated with a Superfund site can be significant. Annual O&M costs were available for six of the eleven NPL sites studied in this paper. Costs ranged from only two percent of capital costs annually at New Lyme Landfill to 56 percent at Hollingsworth. (See Table 13.) Based on an assumption of 20 years of O&M per site (many estimates are based on 30 year or even 75 years), the total cost of operations and maintenance at two of the six sites is greater than total capital costs.

Table 13

Operations and Maintenance Costs Compared to Capital Costs at 11 NPL Sites

Site	State	In Data Base	Medium Contaminated	Total Capital Cost	Annual O&M as % of Capital Cost	Total O&M Based on 20 Years
Bayou Bonfouca	LA	Yes	soil/groundwater	$60,497,534	<1%	$3,474,960
Lipari Landfill	NJ	Yes	soil/groundwater	$26,233,150	21%[1]	$14,300,000
Hollingsworth	FL	Yes	soil/groundwater	$653,730	56%	$7,284,300
New Lyme Landfill	OH	Yes	soil/groundwater	$10,798,000	2%[2]	$5,040,000
Moyer Landfill	PA	Yes	soil/groundwater	$6,298,500	5%	$6,640,000
Sacramento Army Depot	CA	Yes	soil/groundwater	$7,398,414	15%[3]	$5,280,000
Langley Air Force Base	VA	No	groundwater	$569,739	32%[4]	$35,961,20 [5]
McClellan AF Base	CA	No	groundwater	$4,000,000	31%	$24,800,000
Twin Cities Army Ammunition Plant	MN	No	groundwater	$8,000,000	7%	$11,780,000
Savannah River (DOE)	SC	No	groundwater	$4,130,000	4%	$29,840,000
Hill Air Force Base	UT	No	soil	$115,000	21%	$24,000[6]

Sources: Ruth Ruttenberg & Associates, Inc. Data Base; Interviews and Correspondence with Site Officials and Contractors; EPA and Member Agencies of the Federal Remediation Technologies Roundtable, Remediation Case Studies.

[1] Of the 1 remedial action that requires O&M
[2] Based on annual O&M of $252,000 which is supposed to decrease to $44,000 annually, at an undetermined time
[3] For the one RA which required O&M
[4] Year 1 and year 2 O&M costs averaged,another source says after year 1 operating costs will be $110,000
[5] Year 1 and year 2 O&M costs averaged.
[6] $24,000 over 4 years.

2. Total Estimated Job Generation from RCRA Site Cleanup

Cost of Cleaning up RCRA Sites

Assuming that there are 4,700 RCRA TSD sites to be cleaned up, with an expenditure of at least $230 billion, then an estimated total of 1,080,979 job years are generated. Of this 928,370 job years are estimated for direct remedial action and 152,609 job years are estimated for O&M activities. This estimate is based on the following assumptions: that 15 percent of RA dollars, on average, are allocated to direct construction labor; that average hourly earnings are $18.40; and that 1500 hours constitute a full-time job for a year, while 2000 hours constitute a full-time job for a year of O&M work.

Total cleanup costs for RCRA sites is significantly higher than for NPL sites, with many estimates reaching $230 billion or more. While, in aggregate, assumed to be over $230 billion, the range of possible total costs from the University of Tennessee study was $130 billion to $450 billion, with a most appropriate range estimated at $203 billion to $265 billion (the average estimates for the least stringent and most stringent estimates).[97] But the total range, based on less stringent and more stringent requirements is very broad -- $105 billion to $600 billion. An estimate of environmental remediation costs in 1993[98] found that nearly one-third of the entire estimated cost for environmental remediation, a total of well over $450 billion, would be used to clean-up sites covered by RCRA. Cost estimates for RCRA sites may, however, be somewhat less accurate than estimates for NPL sites because most have not been well evaluated.[99]

There are at least eight different categories of RCRA sites,[100] but over 40 percent of the burden fell to the cleanup of tanks and tank areas. Landfills, surface impoundments, and container areas accounted for 13 percent to 17 percent each of the total cost, and waste piles, land treatment units, and satellite areas accounted for 3 percent to 6 percent each of total RCRA cleanup cost.

Duration of Activities

The duration of a RCRA site cleanup is expected to be quite long, especially for O&M.[101] Some cleanups, such as those requiring soil excavation and treatment, may have as little as two, four, or six years of O&M. Sites requiring pump and treat are more likely to require five, twenty, or one hundred years of O&M. The Cost of Remedial Action (CORA) Model developed for EPA by CH2M Hill in 1989, used a 60 year period for soil and RCRA caps, which included one replacement cap and 60 years of operations and maintenance (O&M).

3. Total Estimated Job Generation from DOE Site Cleanup

A total of 1,108,696 remedial action and O&M job years are projected to be generated for hazardous waste cleanup of the DOE nuclear weapons complex. This estimate is derived from the University of Tennessee's best estimate of $240 billion, using the assumptions that: remedial action costs are 73 percent of the total restorations costs and O&M costs are 16 percent of the total restoration costs; 15 percent of RA dollars, on average, are allocated to direct construction labor; average hourly earnings are $18.40; and 1500 hours constitute a full-time job for a year, while 2000 hours constitute a full-time job for a year of O&M work.

Total Estimated Job Generation from DOE UMTRA Sites

UMTRA represents a small portion of the cleanup work at DOE and the number of job years generated at UMTRA sites is only one percent of those generated at all DOE sites, with 11,183 remedial action jobs expected. (These projections assume that RA represents 73 percent of total cost, that direct construction labor accounts for 15 percent of RA. Average hourly earnings used are those generate by craft from the RRA data base and 1500 hours are assumed to constitute a full-time equivalent work year for a construction worker.)

The major operations and maintenance task at UMTRA sites is to treat contaminated groundwater. According to one expert,[102] this is expected to last through 2014 (19 years) and cost $7.8 million per year, all 19 years, for a total cost of $148.2 million (six percent of the remediation cost) with treatment mostly through natural attenuation rather than pump and treat.

For remedial actions jobs by craft for all UMTRA sites see Table Y.

Cost of Cleaning Up DOE Sites

Funding for DOE cleanup programs is set at $12.3 billion for 1994 through 1998, with estimates of the total cleanup cost growing to the hundreds of billions of dollars. The University of Tennessee best estimate for cleanup of the DOE complex is $240 billion. DOE's mid-range estimate of its cleanup cost is $230 billion.[103]

Cost of Cleaning Up DOE UMTRA Sites

Cost estimates for cleanup of UMTRA sites were also made by the General Accounting Office (GAO) in 1995.[104] GAO estimated the overall costs for the 23 UMTRA sites to be $2.315 billion, with at least 85 percent of those funds spent by year end 1995. The four UMTRA sites studied in this report range from the most expensive (Grand Junction) of the 23 sites to the 16th most expensive. Together the four sites account for 47 percent of total projected cleanup costs at the 23 UMTRA sites ($1.082 billion of $2.315 billion). The Grand Junction site alone accounts for 32 percent of the total

UMTRA cost, at $746 million.

4. Total Estimated Job Generation from DOD Cleanup

Using the University of Tennessee's best estimate of the cost of DOD cleanup at $30 billion, 138,587 job years will be needed for remedial action and O&M activities over the next thirty years. This estimate is based on the assumptions that remedial action costs are 73 percent of the total restorations costs and O&M costs are 16 percent of the total restoration costs.

The Cost of Cleaning Up DOD Sites

The total estimated cost for all IRP activities over the next 20 years, according to EPA, is $24.5 billion.[105] The University of Tennessee estimated a total cost for cleanup of DOD sites at $30 billion and DOE estimated DOD cleanup costs at $25 billion. A 1991 EPA report estimated the RD/RA costs for DOD were $15.4 billion, of which $14 billion was to be for remedial action.[106] In addition, EPA experts estimated operations and maintenance (O&M) to cost $4 billion (consistent with DOE's estimate of DOD's 1992 O&M costs at $4.1 billion).

5. Total Estimated Job Generation from UST Cleanup

An estimated 309,511 job years are needed -- for both remedial actions and O&M activities -- to clean up petroleum and other hazardous wastes from the nation's underground storage tanks. Of this total 265,815 job years are for direct remedial action, and 43,696 job years are for O&M. This assumes that the total for UST cleanup is $67 billion,[107] that 73 percent of dollars allocated are for remedial action, that 15 percent of RA dollars are allocated to direct construction labor, that 1500 hours represent of a full time construction job, and that average hourly earnings are $18.40. The operations and maintenance estimate of 43,696 job years assumes that O&M costs are 16 percent of remediation costs ($67 billion), that construction labor costs are 15 percent of total RA costs, that average hourly earnings is $18.40 and 2000 hours represent a full-time job for a year.

Cost of Cleaning Up UST Sites

The University of Tennessee's best estimate for cleaning up UST sites is $67 billion. However, as the findings show, many factors need to be taken into consideration when developing that total cost estimate.

Number of Sites and Cost of UST Cleanup

There are several different estimates on the number of underground storage tanks existing and in need of cleanup:

- According to EPA, as of 1993, approximately 295,000 UST sites, containing at least 56 million cubic yards of contamination, required cleanup.[108] This includes 119,000 confirmed releases that have not been cleaned up yet, in addition to 176,000 projected releases. Previous studies have indicated that remedial costs per site can range from $2,000 to $400,000 with an average of $100,000.
- As of October 30, 1995 there were 1,093,105 active tanks registered and 983,877 closed tanks. There had been 303,635 confirmed releases, 239,671 cleanups initiated, 113,512 enforcement actions, and 8,600 emergency responses. Completed tank remediations numbered 90,529.[109]
- When groundwater as well as soil are contaminated, there may be significant operations and maintenance costs. Those UST sites with groundwater contamination cost as much as 10 times more than tanks having only soil contamination ($125,000 to over $1 million vs. $10,000-$125,000).[110]

6. Total Estimated Job Generation from State and Private Site Cleanup

An estimated 138,587 job years are needed for both remedial and O&M activities to cleanup state and private sites. Of this, 119,022 job years are for direct remedial action, and 19,565 job years are O&M activities. This estimate is based on the assumptions that remedial action costs are 73 percent of the total restorations costs and O&M costs are 16 percent of the total restoration costs; that 15 percent of RA dollars, on average, are allocated to direct construction labor; that average hourly earnings are $18.40; and that 1500 hours constitute a full-time job for a year, while 2000 hours constitute a full-time job for a year of O&M work.

Of the sites identified by EPA, ASTSWMO, and Kensington; 2,844 had remedial construction completions (2689 State/Territory and 155 Federal) and 20,134 sites were still in the remedial process, with at least a preliminary assessment (11,000 State/Territory and 9,134 Federal).

If the sites completed or with major decisions about remediation are comparable to the universe of identified sites, then approximately 14 percent of the remedial actions and 36 percent of the removal sites had been completed by year end 1992.

Cost of Cleaning Up State and Private Sites

University of Tennessee study in 1991[111] estimated that each state or private sector site cleanup would cost an average of $1 million, for a total resource commitment of between $12 billion and $32 billion. Two separate analytic approaches were used by the University of Tennessee in making these estimates and "the two approaches tracked each other exceptionally well." The study estimated that through the year 2020 there would be 24,335 state sites requiring cleanup.[112] The University of Tennessee estimated that five to fifteen as many non-Federal program sites exist as are listed on the NPL and as are at Federal facilities.[113]

The data from approximately 3,500 sites provided costs for remediation of over $1.2 billion. (See Table Z.) The average site cleanup cost for state sites ranged from under $3,000 in Oklahoma to over $3 million in Colorado. For 18 of the 31 states that provided site data, the average costs were between $50,000 and $500,000. For PRP sites the average ranged from $1000 in Indiana to $7 million in Utah, with the largest number of estimates between $200,000 and $500,000.[114]

State sites usually cost less than federal sites to cleanup. For remedial actions studied by EPA,[115] the average federal remedial construction completion cost $2.4 million whereas the average state completion cost $183,000. For completed removals, EPA reported an even greater difference between the average cleanup cost of a federal and a state site -- $7.1 million and $47,000, respectively.

Cost data are probably more reliable from some states than from others, due to higher levels of experience. New Jersey, for example, has completed 925 remedial actions and Massachusetts and Michigan more than 300 each, while 25 states reporting had less than 10 completions. (See Table V.)

NUMBER OF EMPLOYMENT EPISODES LIKELY TO BE HIGHER THAN ESTIMATED JOB YEARS

Because of peak work time at a site, at least three times as many individuals may perform work as estimated job years may predict. (See Table 14.) The demand for an individual's skills may be for only a few hours, days, or months based on subspecialty, task at hand, etc. These estimates do not include the need to cover absenteeism, turnover, and the need for individuals with highly specialized craft skills within a trade. On the other hand, because job projections are made in job years, there may be some offsetting reductions for individuals who work more than one full-time job year.

Peak time demand results primarily from the specialization of trades on a site and the need to hire specific individuals to perform specific tasks, and sometimes tasks of relatively brief duration. So, for example, at a specific site, like Bridgeport (BROS) in New Jersey, where averaged over the period of remedial action there was a requirement for an average of 59 workers a month, in the month of peak demand for workers, 203 were needed -- thus an overall site demand for 234 percent more individuals than the overall average would suggest. For plumbers and pipe fitters at BROS, however, the peak demand is 100 percent higher than average; for iron workers it was 900 percent higher; for electricians it was 450 percent higher; for laborers, operators, and drivers the demand was approximately double.

It is not enough to simply estimate demand for the amount of labor time on an environmental remediation job. One must focus on the total number of individuals who will be working on a site. This is not a simple arithmetic calculation:

- Simply Estimating Number of Hours To Be Worked May Not Be Accurate. Even if one could accurately estimate the number of labor hours to be worked on a site, using this as a basis for calculation would be misleading. Estimating employment episodes by estimating the number of hours of work and dividing by a full-time worker equivalent; say, 1500 hours for a construction worker, is a way to get a rough estimate, but this method is misleading, because remediation work is not spread evenly among crafts.

- Estimating Number of Hours By Craft May Not Be Accurate. While somewhat more accurate for estimating training needs, estimating the number of hours of work by craft divided by a full-time equivalent number of hours is also not enough, because work is not spread evenly over time, especially not by craft. For example, if there is a large decontamination pad to be built, a site is likely to employ a significantly larger number of iron workers and carpenters than another site. At some sites there is a more prevalent share of heavy equipment operators. At others there is a high percentage of drillers or electricians or laborers. Labor mix depends on the type of remediation, management decisions, and a number of other factors.
- Estimating Number of Hours By Craft By Month Makes Estimates More Realistic. More accurate than an assessment of overall labor requirements or overall labor requirements by craft, is to determine the peak month of work at a site for each craft and determine what number of individuals, at a minimum, would need to be employed to meet those peak month demands. At one site, Rifle, the peak month required more than 6 times the number of workers than the average month. (See Table 14.) At Bog Creek, Bonfouca, and New Lyme more than three times the number of workers were needed. On average for the sixteen sites, 332 percent more employment episodes were needed, based on peak month estimates, than would have been expected from average month labor needs.

Table 14

Percent Increase of Employment EpisodesPlanning by Overall Jobs vs. Peak Month Jobs

SITE	A	B	CA	CE	DL	DV	E	I	L	ME	MI	O
Bog Creek	--	--	300%	--	100%	--	333%	300%	300%	--	--	229%
Bonfouca	--	300%	560%	400%	--	250%	400%	633%	300%	--	--	144%
Bros	--	--	133%	--	--	225%	450%	900%	188%	260%	--	191%
Cherokee	--	--	200%	--	--	200%	100%	100%	200%	--	--	200%
Durango	--	--	--	--	--	233%	0%	100%	350%	75%	--	150%
Grand Junction	--	--	--	--	--	300%	--	--	250%	250%	--	250%
Hollingsworth	--	--	--	--	--	--	--	--	0%	--	--	0%
Kem-Pest	--	--	0%	--	--	0%	--	--	150%	--	--	0%
Lipari	300%	500%	350%	500%	350%	200%	150%	500%	271%	--	--	450%
Lone Pine	--	--	0%	--	--	--	--	0%	150%	0%	--	200%
New Lyme	--	--	200%	--	500%	566%	400%	400%	400%	--	--	388%
Paducah	--	--	133%	0%	--	0%	400%	250%	166%	--	--	250%
Rifle	--	--	300%	--	--	622%	100%	--	788%	650%	--	625%
Sacramento	100%	--	--	--	0%	--	0%	--	250%	--	--	100%
Shiprock	--	--	--	--	--	400%	--	--	160%	--	--	181%
South Tacoma	--	--	50%	--	100%	0%	650%	--	167%	--	500%	100%

Table 14, Continued.

SITE	PA	PP	S	W	JOA	PP	S	W	JPMA	%!

Bog Creek	--	550%	--	--	21	550%	--	--	87	372%
Bonfouca	--	--	--	500%	37	--	--	500%	161	335%
Bros	--	1100%	--	--	59	1100%	--	--	203	244%
Cherokee	--	0%	--	0%	11	0%	--	0%	27	145%
Durango	--	--	--	--	44	--	--	--	124	181%
Grand Junction	--	--	--	--	29	--	--	--	111	282%
Hollingsworth	--	--	--	--	2	--	--	--	2	100%
Kem-Pest	300%	--	--	--	5	--	--	--	12	140%
Lipari	200%	260%	--	--	42	260%	--	--	169	302%
Lone Pine	--	--	--	--	4	--	--	--	8	133%
New Lyme	--	100%	200%	--	28	100%	200%	--	143	410%
Paducah	--	300%	--	--	14	300%	--	--	40	186%
Rifle	--	--	--	--	34	--	--	--	253	644%
Sacramento	--	--	--	--	6	--	--	--	13	116%
Shiprock	--	--	--	--	18	--	--	--	54	200%
South Tacoma	--	100%	--	--		100%	--	--	30	233%
							TOTAL	400	1,729	332%

Source: Ruth Ruttenberg & Associates Data Base

Categories:

A - Asbestos	DR - Driver	MI - Millwright	W - Welder	JOA - Job by Overall Average
B - Bricklayer	E - Electrician	O - Operator		JPMA - Job by Peak Month Average
CA - Carpenter	I - Iron Worker	PA - Painter		%! - % Increase
CE - Cement Finisher	L - Laborer	PP - Plumber/Pipe Fitter		
DL - Driller	ME - Mechanic	S - Sheet Metal		

For some trades, the increased number of employment episodes needed, when estimated by peak month, are especially large. At the two sites, Bonfouca and Lipari, where bricklayers made up one percent or more of total hours, the increase was 300 percent and 500 percent respectively. For drivers the increases were as high as 620 percent at Rifle; for laborers at Rifle the increase was almost 800 percent; for iron workers, at BROS, the increase was 900 percent. For plumbers and pipe fitters at Bros the increase was 1100 percent and at Bog Creek 550 percent.

- Estimating Number of Hours By Specialty Within Each Craft, By Month, Would Make Estimates Even More Realistic. These data, unfortunately were not available for this analysis. But it is important to note that many jobs at hazardous waste sites are very specialized. They may require specialized workers to operate a specific type of equipment, and so the number of operator hours in a given month might involve multiple operators even though the total number of hours is less than full-time.

Contractors, for planning and budget purposes, need to be able to estimate the total number of individuals who will be working on the site. The data presented below are based on number of workers by trade by month, and look to the peak month demand for each trade. Even this estimate is an underestimate of need because within each trade are specialities that cannot usually be performed by one individual. Hence, several carpenters or several operators or several iron workers might be needed on a site to perform relatively small specialty jobs -- even though their total work hours might be within the time frame of a single individual. (See Bullet #3.) The estimates made here should still be considered underestimates for two main reasons: 1) there are no provisions made for turnover and absenteeism and 2) within a craft there are subspecialties that may require the hiring of multiple individuals. (See Bullet #4.)

At peak demand, from the year 2000 through 2005, NPL site cleanup alone is likely to generate over 200,000 job years, requiring the employment episodes for as many as 600,000, maybe more, HAZMAT workers.

JOB PROJECTIONS OVER TIME

The arduous task of cleaning up the nation's hazardous waste sites has begun. At what pace it will continue depends on public policy and budget decisions. The projections in this section are based, not on University of Tennessee estimates, but rather on a 1993 study done for DOE,[116] which compiled work plans over time across regulatory bodies and legislative jurisdiction. (See Tables 8 and 15 and Chart 3.) As a result, the number of job years projected in this section of the report does not tightly parallel discussion of job years in other sections. For example, the DOE study projected total cleanup costs over 30 years of $983 billion, higher than the $752 billion estimates of the University of Tennessee. For the 20 years, 1990-2010, for which projections are made in this section, the estimated cleanup costs by DOE are $758 billion -- with higher projected proportionate costs for RCRA and State/Private sites than the UT study and lower proportionate costs for cleaning up DOE sites.

Table 15

Billions of Dollars That Have Been and Will Be Spent on Various Categories of Hazardous Waste Cleanup 1990-2010

Site Category	1990-1995	1996-2000	2001-2005	2006-2010	Total
NPL	$19	$30	$60	$46	**$155**
RCRA	$49	$100	$130	$96	**$375**
DOE	$9	$30	$40	$20	**$99**
DOD	$7	$12	$3	$2	**$24**
UST	$27	$6	$3	$3	**$39**
State/Private	$4	$13	$27	$35	**$79**

TOTAL	$113	$191	$252	$202	**$758**

Source: Department of Energy and Ruth Ruttenberg & Associates, Inc. Data Base.

CHART 3

Using the same assumptions used throughout this report to make projections, remediation job demand is expected to grow by 60 percent, or almost 300,000 jobs, from the 1990-1995 five year period through the five year period 1995-2000 -- from 447,000 to 740,000. (See Table 16 and Chart 4.) Demand for jobs continues to grow by nearly another 300,000 in the 2000-2005 time interval. During this peak period nearly 2 million jobs will require workers. As many as 7.5 million more workers will require training -- either basic or refresher. Demand remains high from 2005-2010 and then begins to taper off -- with a rather optimistic assumption that most cleanup activities will be completed in 25 to 30 years.

Table 16

Number of Expected Remedial Action Jobs Generated by Various Categories of Hazardous Waste Cleanup 1990-2010					
Site Category	**1990-1995**	**1996-2000**	**2001-2005**	**2006-2010**	**Total**
NPL	66,459	104,935	209,871	160,901	**542,166**
RCRA	194,402	396,739	515,761	380,870	**1,487,772**
DOE	35,707	119,022	158,696	79,348	**392,773**
DOD	27,772	47,609	11,902	7,935	**95,218**
UST	107,120	23,804	11,902	11,902	**154,728**
State/Private	15,870	51,576	107,120	138,859	**313,425**
TOTAL	447,330	743,685	1,015,252	779,815	**2,986,082**

Source: Department of Energy and Ruth Ruttenberg & Associates, Inc. Data Base.

CHART 4

Craft labor demand is projected for the years 1990-2010. (See Table 17 and Chart 5.) More than 900,000 year long jobs are expected for operators 1990-2010, suggesting training needs approaching 3 million. Nearly one million laborers and several hundreds of thousand plumbers, pipe fitters, carpenters, electricians, truck drivers, iron workers, mechanics, cement workers, and others will require hazardous materials training to complete the ambitious task of safely cleaning up the hazardous waste sites of this nation.

Table 17

Number of Expected Remedial Action Jobs by Craft, By Years for Hazardous Waste Cleanup 1990-2010					
Craft	**1990-1995**	**1996-2000**	**2001-2005**	**2006-2010**	**Total**
Operator	125,163	211,558	279,124	223,742	**839,587**
Laborer	99,197	167,669	221,218	177,325	**665,409**
Plumber/PF	15,542	26,270	34,660	27,783	**104,255**
Carpenter	14,903	25,191	33,236	26,641	**99,971**
Electrician	15,067	25,467	33,600	26,933	**101,067**
Driver	50,422	85,226	112,445	90,134	**338,227**
Iron Worker	7,808	13,197	17,412	13,957	**52,374**
Mechanic	19,195	32,444	42,806	34,313	**128,758**
Other	94,146	159,132	209,954	168,297	**631,529**
Total	441,443	746,154	984,455	789,125	**2,961,177**

Source: Department of Energy and Ruth Ruttenberg & Associates, Inc. Data Base.

CHART 5

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INSTITUTIONAL CONTACTS

- ACCI, ASRC Contracting Company, Inc., Sacramento, California

- Air Force Center for Environmental Excellence, San Antonio, Texas
- American Federation of Labor - Congress of Industrial Organizations, Washington, D.C.
- Alameda County Economic Development Program, Oakland, California
- Alice Hamilton Occupational Health Center, Washington, D.C.
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- Clean Sites, Alexandria, Virginia
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- New Jersey Department of Labor, Newark, New Jersey
- New Jersey State Police Department
- Office of the Mayor, Sacramento, California
- Operating Engineers, International Union of, Washington, D.C.
- Operating Engineers Local Union No. 3, Alameda, California
- Pacific Studies Center, Mountain View, California
- Perry Nuclear Power Plant, Ohio
- PRC Environmental Management, Inc., San Francisco, California
- Radian Corporation, Sacramento, California
- Santa Clara County Building and Construction Trades Council, Santa Clara, California
- Sheet Metal Worker's International Association, Washington, D.C.
- State of California, Office of the Governor, Office of Emergency Services, Hazardous Materials Unit, Sacramento, California
- Teamsters, International Brotherhood of, Washington, D.C.
- Teamsters, Northern California, Rancho Murieta, California
- Texas Department of Public Safety, Austin, Texas
- Texas General Land Office, Oil Spill Prevention and Response Division, Austin, Texas
- United Brotherhood of Carpenters and Joiners, Washington, D.C.
- United States Air Force
- United States Army Corps of Engineers, Philadelphia District
- United States Army Corps of Engineers, Baltimore District
- United States Department of the Army, New York District, Corps of Engineers
- United States Department of the Army, Philadelphia District,Corps of Engineers
- United States Department of Energy, Office of Environmental Management
- United States Environmental Protection Agency, Headquarters, Office of Solid Waste and Emergency Response, Washington, DC
- United States Environmental Protection Agency, Region II
- United States Environmental Protection Agency, Region III
- United States Environmental Protection Agency, Region IV
- United States Environmental Protection Agency, Region V
- United States Environmental Protection Agency, Region VII
- United States Environmental Protection Agency, Region IX
- United States Navy
- University of California, California Consortium, Los Angeles, California
- University Of Medicine & Dentistry of New Jersey, Piscataway, New Jersey
- Waste Solutions Group, San Francisco, California
- Westinghouse Remediation Services, Inc., Tampa, Florida

FOOTNOTES

[1] United States General Accounting Office, High Risk Series, Superfund Program Management, GAO/HR-93-10, Washington, DC, December 1992.

[2] U.S. Department of Energy, Manpower Assessment Brief, Number 26, August 1994, p.1.

[3] U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Program Management, Policy and Contracts Assessment Staff, Economic Impact of the Superfund Program: Fiscal Years 1981-1992, Draft, July 1994, p. 12.

[4] Ibid.

[5] United States General Accounting Office, Report to Congressional Requestors, HAZARDOUS WASTE: DOD Estimates for Cleaning Up Contaminated Sites Improved but Still Constrained, Washington, DC, October 1991.

[6] U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Program Manger, Policy and Contracts Assessment Staff, DRAFT Technical Report, Economic Impact of the Superfund Program: 1981-1992, Washington, DC, June 16, 1994.

[7] The Davis-Bacon Act provides prevailing wage protection to non-governmental workers. It requires the payment of prevailing wages and fringe benefits to craft labor employed by contractors and subcontractors engaged in federal construction projects.

[8] See Appendix II for brief summaries of the sites. (See Table A in Appendix III for comparison of site characteristics.) All lettered tables may be found in Appendix III. Many dozens of tables and charts were developed over the course of this study. The most important summary tables and charts are integrated into the text of the report and are numbered; i.e., 1,2,3, etc. Twenty-six other summary tables are referred to in the text and are found in Appendix III. These tables are identified by letter; i.e., A through Z. Site specific tables and dozens of other tables while not integrated into this report, are listed in Appendix IV and are available on request.

[9] Because one site, Lone Pine, provided daily labor logs rather than certified payrolls, some data for that site were not available. Hence, sometimes the number of key sites cited in the study is 18 and sometimes 17; sometimes the number of NPL sites in the RRA data base is given as 12 and sometimes as 11. For another site -- Hollingsworth -- payrolls are similar to Davis Bacon certified payrolls, but the site is private and not covered by prevailing wage requirements.

[10] See Appendix VI for acronyms and Appendix VII for glossary.

[11] Eight major remedial action categories as defined by E.W. Colglazier, T. Cox, and K. Davis, Estimation of Resource Requirements for NPL Sites, Waste Management Research and Education Institute, University of Tennessee, Knoxville, December 1991.

[12] R.S. Means Company, Inc., ECHOS 1996 Environmental Restoration Cost Books Assemblies Costs/Unit Costs., Kingston, MA, 1996.

[13] While, on average, at the 17 certified payroll sites studied by RRA, drivers earned 10 percent of the certified payroll, at NPL sites they only earned 4 percent, and at removal sites, only 1 percent. According to certified payrolls from DOE UMTRA sites, on the other hand, drivers earned 28 percent of the payroll. Most likely, more drivers were employed in association with cleanup at all these sites, but truck driver jobs often seem to elude Davis Bacon coverage, thus eliminating them from certified payrolls. In 1987 when OSHA developed work force estimates for laborers, operators, and truck drivers at both small and large hazardous waste sites, it found a higher level of demand for truck drivers than is reflected in the RRA data base. [U.S. Department of Labor, Occupational Safety and Health Administration, Office of Regulatory Analysis, Prepared by Eastern Research Group, Inc., Preparation of Data to Support a Regulatory Analysis and Environmental Impact Assessment of the Proposed Standard for Working at Hazardous Waste Sites, Draft Final Report, Washington, DC, April 1987.] The small sites were primarily landfills. At these sites, OSHA's consultant estimated laborers to be 13 percent, operators 21 to 26 percent, and truck drivers 20 to 25 percent of the total work force. Other categories included supervisors, chemists, and security personnel. At large sites, usually involving drums and soil contamination, OSHA's consultant estimated that laborers would make up 35 to 38 percent of the workforce, operators 39 to 42 percent, and truck drivers 16 to 19 percent.

[14] Bayou Bonfouca, Bog Creek Farm, Bridgeport Rental and Oil Services, Durango, Grand Junction, Hollingsworth, K-25, Lipari, Paducah, Rifle, Sacramento Army Depot, and Shiprock.

[15] Environmental Protection Agency, Office of Research and Development, Survey of Materials-Handling Technologies Used at Hazardous Waste Sites, EPA/540/2-91/010, Washington, DC, June 1991, p.13.

[16] Sacramento Army Depot, CA; Hollingsworth Solderless, FL; Paducah Gaseous Diffusion, KY; Bonfouca, LA; Kem-Pest, MO; Bog Creek, NJ; BROS, NJ; Lipari, NJ; Lone Pine, NJ; New Lyme, OH; Moyer, PA; and K-25 Oak Ridge, TN.

[17] Bonfouca, Bridgeport (BROS), Lipari, Moyer.

[18] Payroll data collected ranged from a low of $39,000 at Hollingsworth to $15 million at BROS. (See Table A.)

[19] U.S. Department of Energy (EM-24), Prepared by Independent Project Analysis, Inc., The Demand for Environmental Restoration Services, Draft, 93-DOE-007, Washington, DC, May 1993, p. 1-9.

[20] Doty Carolyn, Amelia Crotwell, and Curtis Travis, Cost Growth for Treatment Technologies at NPL Sites, December 1991; EPA and Member Agencies of the Federal Remediation Technologies Roundtable, Remediation Case Studies: Groundwater Treatment, March 1995; EPA and Member Agencies of the Federal Remediation Technologies Roundtable, Abstracts of Remediation Case Studies, March 1995; U.S. DOE, Estimating the Cold War Mortgage: The 1995 Baseline Environmental Management Report. March 1995.

[21] Interview, Terry Eby, EPA, Emergency Response Division, Washington, DC, April 1996.

[22] EPA, with the Association of State and Territorial Solid Waste Management Officials (ASTSWMO), "Underground Storage Tank and Leaking Underground Storage Tank Study," November 6, 1995.

[23] U.S. Environmental Protection Agency, Solid Waste and Emergency Response, EPA 542-R-92-012, Cleaning Up the Nation's Waste Sites: Markets' and Technology Trends, Washington, DC, April 1993.

[24] Environmental Protection Agency, Office of Solid Waste & Emergency Response, The Nation's Hazardous Waste Management Program at a Crossroads: The RCRA Implementation Study, EPA/530-SW-90-069, Washington, DC, July 1990, p.7 and U.S. General Accounting Office, Hazardous Waste: Status and Resources of EPA's Corrective Action Program. GAO/RCED-909-144, Washington, DC, April 1990, p.1.

[25] OMB, Information Clearance, appearing in the Federal Register, April 1, 1996.

[26] U.S. Department of Energy, Fernald Field Office, Operable Unit 3: Record of Decision for Interim Remedial Action, Fernald Environmental Management Project, Fernald, Ohio, May 1994.

[27] Ibid., p.20.

[28] U.S. Department of Energy, Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1994-1998, Installation Summaries, Vol.2, DOE/S-00097P, Washington, DC, January 1993, p.II-68.

[29] U.S. General Accounting Office, Uranium Mill Tailings: Cleanup Continues, but Future Costs Are Uncertain, GAO/RCED-96-37, Washington, DC, December 1995, pp.25-26.

[30] Houghton, Aimee, and Lenny Siegel, Military Contamination and Cleanup Atlas for the United States - 1995, The Pacific Studies Center and CAREER/PRO, San Francisco State University, San Francisco, CA, 1995, p. 2.

[31] Ibid., p. 3.

[32] U.S. Department of Defense, Defense Environmental Restoration Program Annual Report to Congress for Fiscal Year 1992, Washington, DC, April 1993, p. 3.

[33] EPA, Cleaning Up the Nation's, p. 63.

[34] United States General Accounting Office, Hazardous Waste: Tinker Air Force Base is Making Progress in Cleaning Up Abandoned Sites, GAO/NFIAD-87-164-BR, Washington, DC, July 10, 1987.

[35] Underground storage tanks are any tanks that have at least 10 percent of their volume buried below the ground, including piping connected to the tank.

[36] EPA, Cleaning Up the Nation's, p. 53.

[37] Lenny Siegel, "Jobs From a Typical Cleanup Task: Underground Storage Tank Removal," Pacific Studies Center, Mountain View , CA, September 1994.

[38] Assumed here is that the labor share for off-site treatment and disposal is equal to the labor share for removal of tanks and piping.

[39] While the typical gasoline tank is 12,000 gallons, those at defense facilities are sometimes larger, with additional operator labor needed.

[40] EPA, OUST, Data Sheet, September 30, 1995.

[41] U.S. General Accounting Office, Hazardous Waste Sites: State Cleanup Status and Its Implications for Federal Policy, GAO/RCED-89-164, Washington, DC, August 1989, p.12.

[42] Kensington Systems, Inc., "State and Territory System Documentation," for the U.S. Environmental Protection Agency, Washington, DC, August 1994.

[43] All data were not available for all sites. There is information on the status and type of site from 37 states and 22,902 sites. There is information on the duration of projects from 27 states and 5904 sites. There is information on predominant remedies from 31 states and 15,990 sites. There is cost information from 30 states and 3,552 sites. For a list of which status reported on which data. (See Appendix III.)

[44] U.S. Environmental Protection Agency with Association of State and Territorial Solid Waste Management Officials (ASTSWMO), A Report on State Territory Non-NPL Hazardous Waste Site Cleanup Efforts for the Period 1980-1992, OSWER 9242.2-09, PB 94-963422, July 1994, p.ES-5.

[45] DOE, The Demand for Environmental Restoration Services.

[46] Kensington System, Inc., "State and Territory System Documentation."

[47] EPA with ASTSWMO, p.ES-8.

[48] Ibid., p. ES-6.

[49] While there is also preparatory work, disposal activities, and demobilization activities as general work areas for environmental remediation, containment and treatment are the most significant activities.

[50] U.S. Environmental Protection Agency, Innovative Treatment Technologies: Annual Status Report (Seventh Edition): Applications of New Technologies at Hazardous Waste Sites, EPA-542-R-95-008, Washington, DC, September 1995, p.6.

[51] Ibid., p.2.

[52] Doty, Carolyn, Amelia Crotwell, and Curtis Travis, Cost Growth for Treatment Technologies at NPL Sites and Groundwater Pumping as a Restoration Technology.

[53] DOE, The Demand for Environmental Restoration Services.

[54] U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Presumptive Remedies: Policy and Procedures, Directive: 9355.0-49FS, Washington, DC, September 1993.

[55] Based on comments by John Moran, International Union of Operating Engineers, July 1996.

[56] Interview with Les Murphy, then International Association of Fire Fighters (currently with Black & Veatch International), Washington, DC, April 30, 1993.

[57] Arizona data came from the Arizona Hazardous Materials Incidents Reports (AHMIR), the Emergency Response Notification System (ERNS) data sheets, and Fire Department reports on hazardous incidents. California data were compiled from a report of the State of California Office of Emergency Services on Hazardous Materials Incidents. New Jersey data is from hazardous materials incident reports of the New Jersey Department of Environmental Protection.

[58] These included illegal dumping along the side of the road as well as those that were directly transportation related.

[59] As studied by the Agency for Toxic Substances and Disease Registry and reported in Washington Post, "Caution: HAZMATS Ahead," Health Section, September 20, 1994.

[60] Based on comments by John Moran, International Union of Operating Engineers, July 1996.

[61] U.S. Department of Labor, Occupational Safety and Health Administration, Office of Regulatory Analysis, Regulatory Impact are Regulatory Flexibility of the Occupational Safety are Health Standard for Hazardous Waste Operations and Emergency Response (29 CFR Part 1910) Washington, DC, December 14, 1988, p. I.3.

[62] Ibid.

[63] Interview, Mr. Jerome Barkley, Perry Nuclear Power Plant, Ohio, January 17, 1996.

[64] Scruggs, Yvonne, "Environmental Economic Equity: The Potential for Stimulating Job Training and Relieving Minority Unemployment Through Hazardous Waste Clean-Up Operations", Unpublished Document, June 28, 1994.

[65] Note: No data in this study identify race of worker, only a community in which a worker resides. For privacy reasons this study can not identify any individual workers.

[66] Doty, Carolyn, et. al., Cost Growth for Treatment Technologies.

[67] U. S. General Accounting Office, Federal Facilities: Agencies Slow to Define the Scope and Cost of Hazardous Waste Site Cleanups, GAO/RCED-94-73, Washington, DC, April 1994, p.7.

[68] U.S. General Accounting Office, Superfund: EPA Cost Estimates Are not Reliable or Timely, GAO/AFMD-92-40, Washington, DC, July 1992, p.2.

[69] E.W. Colglazier, Mary English, and Milton Russell, Hazardous Waste Remediation: The Task Ahead, Waste Management Research and Education Institute, University of Tennessee, Knoxville, December 1991, p. 16.

[70] DOE, The Demand for Environmental Restoration Services, p. 1-8.

[71] The University of Tennessee (UT) Studies is not without its critics. Some, for example, believe the DOE numbers used by UT to be to low and the RCRA estimates to be too high. Nonetheless, UT numbers have been favorably reviewed by many experts and remain the must comprehensive ones available.

[72] Blaine Harden, "Nuclear Reactions," Washington Post Magazine, May 5, 1996, p.14.

[73] Interview with Dean P. Findley, Independent Project Analysis, Inc., author of The Demand for Environmental Restoration Services, May 1996.

[74] Ibid., p.16.

[75] Doty, Carolyn, Amelia Crotwell, and Curtis Travis, Cost Growth for Treatment Technologies at NPL Sites and the Effectiveness of Groundwater Pumping as a Restoration Technology, Waste Management Research and Education Institute, University of Tennessee, Knoxville, December 1991, p.3.

[76] Federal Register notice 60FR, April 25, 1995 releasing the notice of Sites on the NPL

[77] DOE, The Demand for Environmental Restoration Services, p. 1-9.

[78] Calls to the Superfund Hotline provide a more up-to-data, but unofficial number of sites based on EPA's most recent tracking of deletions and additions to the NPL. The Superfund Hotline estimate on May 21, 1996 was 1223 sites on the NPL.

[79] U.S. Congress, Congressional Budget Office, Prepared by Bender, Peter, The Total Costs of Cleaning Up Nonfederal Superfund Sites, U.S. Government Printing Office, Washington, DC, January 1994.

[80] Cited in U.S. General Accounting Office, Superfund: Estimates of Number of Future Sites Vary, GAO/RCED-95-18, November 1994, p.6.

[81] U.S. Environmental Protection Agency, Elliott Laws, Assistant Administrator, "Responses to 21 Questions" from Hon. John Dingell, U.S. House of Representatives to EPA Administrator Carol Browner, January 28, 1994, Response to Question 1.

[82] Resources for the Future, "RFF Database of Superfund NPL Sites," from World Wide Web, 1995.

[83] DOE, The Demand for Environmental Restoration Services.

[84] U.S. Congress, Congressional Budget Office, The Total Costs.

[85] University of Tennessee, Hazardous Waste Remediation Project, Knoxville, Six Volumes on Hazardous Waste, 1991.

[86] E.W. Colglazier, T. Cox, and K. Davis, Estimation of Resource Requirements, p. 65.

[87] DOE, The Demand for Environmental Restoration Services.

[88] Chemical Manufacturers Association, "Impact Analysis of RCRA Corrective Action and CERCLA Remediation Programs," Washington, DC, CMA, 1988, cited in Shreekant Gupta, George Van Houtven, and Maureen Cropper, "Do Benefits and Costs Matter in Environmental Regulation? An Analysis of EPA Decisions under Superfund."

[89] CBO, The Total Costs.

[90] EPA Hotline, May 1996, current, but unofficial numbers.

[91] Katherine Probst, Don Fullerton, Robert Litan, and Paul Portney, Footing the Bill for Superfund Cleanups, The Brookings Institution and Resources for the Future, Washington, DC, 1995.

[92] Probst, Fullerton, et.al.

[93] Federal Register, Notice 6017.p.20, 330, National Priorities List for Uncontrolled Hazardous Waste Sites, April 1995.

[94] U.S. Congressional Budget Office, The Total Costs of Cleaning Up NonFederal Superfund Sites, CBO, Washington, DC, 1994.

[95] U.S. General Accounting Office, Superfund: Estimates.

[96] DOE, The Demand for Environmental Restoration Services, p. 1-9.

[97] Ibid., pp.47, 49.

[98] DOE, The Demand for Environmental Restoration Services.

[99] U.S. General Accounting Office, Hazardous Waste: Status and Resources of EPA's Corrective Action Program, GAO/RCED-909-144, Washington, DC, April 1990, p.1.

[100] Ibid.

[101] Tonn, Bruce, Milton Russell, Ho-Ling Hwang, Richard Goeltz, and John Warren, Cost of RCRA Corrective Action: Interim Report, Waste Management Research and Education Institute, University of Tennessee, Knoxville, December 1991, p.29.

[102] Interview, David Boram (Belfort), contractor, Department of Energy, April 1996.

[103] DOE's expected length of cleanup is defined as 75 years: 1995 through 2070, U.S. Department of Energy, Office of Environmental Management, DOE/EM-0232, Estimating the Cold War Mortgage: The 1995 Baseline Environmental Management Report, Volume 1, Washington, DC, March 1995, p. 4.16.

[104] Ibid.

[105] Ibid.

[106] EPA, Cleaning Up the Nation's, p. 67.

[107] University of Tennessee "best estimate."

[108] Ibid.

[109] Environmental Protection Agency, Office of Underground Storage Tanks, Data Sheets, October 30, 1995.

[110] Interview with Debbie Tremblay, Office of Underground Storage Tanks, EPA, April 22, 1996.

[111] Day, Sue Markland, Eiman Zeinelabdin, and Andrew Whitford, State and Private Sector Cleanups, Executive Summary, Waste Management Research and Education Institute, University of Tennessee, Knoxville, December 1991.

[112] Ibid., p.12.

[113] Ibid., p.21.

[114] Ibid.

[115] Ibid., p.14.

[116] DOE, The Demand of Environmental Restoration Services.

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Appendices

Appendix I
METHODOLOGY

Objectives

The objective of this study is to describe and project the number and types of jobs in the hazardous waste labor market, by collecting detailed data on the existing U.S. hazardous waste remediation labor force engaged. The focus of data collection has been federal cleanups, because they provide detailed data through Davis Bacon certified payrolls. These federal sites include those under the responsibility of EPA, DOE, and DOD.

Other data collected was from removal actions, through the use of EPA's Removal Cost Management System (RCMS), from state/territory sites with data collected by EPA in conjunction with ASTSWMO, and emergency response forms used in 5 State data bases (three in Arizona, one in California, and one in New Jersey).

Privacy

Protection of individual worker privacy superseded all else in the collection and use of certified payroll data. A protocol was devised, stating exactly which data from the certified payrolls could to be input into the data base developed by Ruth Ruttenberg & Associates, Inc. A disclaimer was drawn up by NIEHS and this contractor, specifically stating that no personal identifiers would be taken from the payrolls and put into the data base. (See Appendix for relevant documents.)

Background Literature Review

Before beginning the process of site selection, a literature review was completed, focussing on relevant studies of hazardous waste employment. Sixteen studies were reviewed and discussed with EPA before the data collection portion of the study began. These studies included: list of tables available but not attached them here. (The literature review is available on requested.) Additional studies were reviewed as work on this report continued.

Site Selection

Two regions of the country were originally chosen for their abundance of hazardous waste site completions. An effort was made to study sites in Southern New Jersey and the San Francisco Bay Area of California. After New Jersey data collection was complete, it became evident that a regional grouping of Northern California sites would be much more difficult to capture, due partially to the fact that the majority of these sites are either private or DOD lead sites. Therefore, a more geographically diverse array of sites was chosen -- an array also diverse in size, responsible party, types of contaminants, and types of remedies.

The objectives of this study were to collect as detailed data as possible on the composition of the existing U.S. labor force engaged in hazardous waste remediation, with a focus on sites on the National Priority List and/or under the responsibility of the U.S. Department of Energy or U.S. Department of Defense. Balancing access to data with an array of labor markets, types of site contamination, and types of remediation technology used was a major struggle. Protecting the privacy of those hazardous waste workers whose efforts were being documented was of the highest priority.

Sites For Which Certified Payroll Data Were Obtained

Certified (Davis Bacon) payroll data were obtained for 17 sites. Daily labor logs were obtained for one additional site - Lone Pine Landfill. The 17 sites for which certified payroll data were obtained included: Bog Creek, NJ; Bayou Bonfouca, LA; Bridgeport Rental and Oil Services, NJ; Cherokee County Site, KS; Durango UMTRA Site, CO; Grand Junction UMTRA Site, CO; Hollingsworth Solderless Terminal Company, FL; K-25 Gaseous Diffusion Plant, TN; Kem-Pest Site, MO; Lipari Landfill, NJ; Moyer Landfill, PA; New Lyme Landfill, OH; Paducah Gaseous Diffusion Plant, KY; Rifle UMTRA Site, CO; Sacramento Army Depot, CA; Shiprock UMTRA Site, NM; South Tacoma Channel, WA.

Sites for which RCMS Data were Obtained

Data from eight federal removal sites were obtained from EPA Regional offices. The data are from EPA's through the Removal Cost Management System (RCMS). These sites were from EPA Regions III, IV, V, and VII, and included: Martinsburg Drum Dump, WV; Carolina Creosotes II, NC; Chemet, TN; Anderson Residential Lead, SC; Bernard Neal, WV; Superior Polishing, MI; Banister Road Drum, MO; and Turner Seed Company, IA.

Sites for Which Qualitative Data or Other Quantitative Data were Collected

Although certified payroll data were not obtained, other data are collected or interviews were held to obtain labor market data from Battery Plant, CA; Ciba Geigy, NJ; Concord Naval Weapons Station, CA; Embarcadero, CA; Hunter's Point Naval Shipyard, CA; McClellan Air Force Base, CA; Pillar Point Air Force Station, CA; Raytheon, CA; Richmond Harbor Dredge Site, CA; Reactive Metals, Inc., OH; Weldon Spring, MO; X-10, Oak Ridge, TN; and Y-12, Oak Ridge, TN.

Other Sites for Which Data was Pursued

Other sites for which data were pursued included McClellan Air Force Base, CA; Mather Air Force Base, CA; Fairchild, CA; Fort Ord Army Base, CA; Granite City Steel, IL; Raytheon, CA; and Intel, CA and a large number of other federal removal sites. Certified payroll data for these sites were not obtained either because significant cleanup work had not yet started or because the potentially responsible parties were unwilling to share data on the site.

Types of Data, Their Acquisition, and Methods for Input and Analysis

For the purpose of this study, nearly 100,000 records of payroll data across numerous sites have been collected. There are more than 100 tables and 40 charts which have been developed to assist in making labor market projections. Numbers and computations have been checked, but given the volume of data, some clerical or mathematical errors may still exist.

To the extent possible, this study used certified payrolls as its primary data source. A certified payroll is a record of payment from either a contractor to a subcontractor or from a contractor to whomever it is for whom they work. These records are kept on all Fund-lead projects and include all persons who were paid during a pay period (typically one week). They contain the worker's name, address, social security number, hours workers (both standard and overtime), hourly pay rate, and job category. (See Appendix for example) For Lone Pine, daily labor logs, rather than certified payrolls, were obtained. These gave significant detail, but were different from payrolls -- data were reported in person-days rather than in hours and no wage data were supplied. (See Appendix for example)

For most of the sites studied, certified payrolls were available for only a portion of the remediation work. More often the payrolls represented discrete tasks such as constructing a decontamination pad, building a pump and treat system, or drilling wells. For some sites there are data gaps for specific months, due either to lack of work at the site for that month or simply due to missing data. In at least one instance, at the Grand Junction UMTRA site, there was a period of two weeks during which there was no work, but limited stand-by pay - because of a work site fatality.

For one site, Hollingsworth Solderless Terminal Company, the payroll data received were regulated by provisions of the Davis-Bacon Act (which requires that federal contractors pay prevailing wages at their construction sites.). Hollingsworth is a non-union plant and industrial workers who were maintaining a pump and treat system.

Institutions with data were identified and contacted. Examples of these institutions include cleanup contractors, EPA area offices, DOE field offices, and the Army Corps of Engineers. Each was provided with a fact sheet on the study, data collection protocol, and a non-disclosure statement. If access to data was granted, data were processed in one of the following three ways: copied by staff of Ruth Ruttenberg & Associates, Inc., (RRA). for later entry into the data base created for this study; reviewed by staff of RRA at contractor offices and needed information directly put into the automated data base; or data were assembled at the contractor office and shipped to RRA for data input.

In no instances were the names, addresses, or social security numbers of an individual identified in the data base established by RRA. Only job category, town of residence, and information about hours and pay were recorded. After data input was completed, any data in possession of RRA were permanently destroyed.

Data Not Collected

An undetermined number of workers are trained as well as in their particular craft, but (emergency responders). The number of trained emergency responders on site is not included. Many changes are made on-site once work begins and unexpected problems often appear. Remedies laid out in the RI/FS and the proposals are often not the specific remedy that is implemented. Completed follow-up on there changes was not done.

RCRA sites, small sites, and site cleanups staffed by on-site industrial workers are under-reported in this study. To some degree this is a result of not gaining the technical support necessary to use the EPA CERCLIS data base.

This study was aided greatly by the help of staff at the Army Corps of Engineers, the Department of Energy, and EPA who allowed this contractor access to payroll records.

Some Problems with the Data From Certified Payrolls and Daily Labor Logs

Data for ten sites in this study were collected from certified payrolls and daily labor logs. While certified payrolls and daily labor logs are exacting sources of data, even they don't provide for a totally consistent and accurate picture of work and wages for a given week. Adjustments to payroll, varying ways of counting hours and benefits, incomplete entries, and technical problems with duplicating records are just some reasons why there are some problems in clearly interpreting all the data. Within a given site there were many subcontractors, and each subcontractor had its own way of delineating job categories. Not each site or subcontractor defines job category in the same way. The treatment of apprentices and journeymen is sometimes as a group and sometimes within a specific trade. Some payrolls include hourly white collar workers and some do not. Below are examples of some of these data problems -- first for payroll data and then for equipment lists:

For all databases, all hourly rate averages were computed only from those records for which the hourly rate was greater than zero.

Lack of Standardization in Field Names

Category names are similar, but not necessarily the same between databases, and between tables. On some tables carpenters and millwrights have been combined, on others they may not have been (although this problem may have been corrected in recent days). There may also have been instances where, for example, in some cases carpenters and millwrights were combined into the category "carpenter", while in other cases they might have been combined into a category called "carpenter/millwright", which may leave the reader questioning the exact composition of our categories.

In all instances, entries in the "category of worker" field were combined into groupings large enough to easily handle and analyze, yet small enough to be meaningful. For example, "laborer" and "laborer special" were combined into "laborer," "equipment operator" and "operating engineer" were combined into "operator," "asbestos 14" and "asbestos 89" were combined into "asbestos," and "truck driver," "driver," and "teamster" were combined into "truck driver."

Lack of Standardization of Procedures

Database queries can be very complicated sometimes, and slight variations can lead to large discrepancies in the data pulled. Sensitivity analysis around some of these variances would be useful in the future.

Lack of Complete Data Per Record

For many entries all data was not available from the certified payroll or daily labor log.

Some categories have been combined across sites, e.g., drivers and truck driver; plumbers and pipe fitters; carpenters and millwrights. They could be dis-aggregated if useful for research. At Hollingsworth, the definition of laborer may not be consistent with the construction labor category used for the other nine certified payroll sites.

In the effort to determine where workers lived, there were often many gaps. For some sites gaps were more severe than others, so that, for example, gross pay for those cities included in the Bog Creek Farm data base were only $231,000 of a gross payroll of $2.2 million.

In instances where data for a month or more is missing from a data base, the reason may have been that there was no remediation work on site; it may have been that the records were not supplied.

For hourly-rate by category tables: categories for which all records listed $0.00 as the hourly rate were not included on the table (for instance, "project manager" for the Rifle database).

Certain non-category items were included in the category field of several databases, including: "other NECA earnings," "holiday," "rain out," "sick time," "vacation pay," "retro pay," and "travel time." These categories and the pay fields of these records were not included in most tables.

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Appendix II
SITES IN THE DATA BASE

BAYOU BONFOUCA is an abandoned creosote works facility in Slidell, Louisiana. It is characterized by standing water and saturated surface soil. The creosote plant treated pilings for use in railway construction. The site was listed on the National Priorities List in December 1982. Remedial action has included excavation, transportation, and disposal of creosote waste and the upper six inches of contaminated soil beneath the creosote piles and debris at a RCRA landfill facility; transportation and disposal of contaminated water by deep-well injection at an approved RCRA facility; excavation and onsite incineration of creosote waste piles and heavily contaminated bayou sediment; RCRA cap; and the pumping and treatment of groundwater.

BOG CREEK FARM, located in Howell, Township, Monmouth County, New Jersey, contains a bog, pond, and trench in a 4-acre disposal area within a 12-acre property. The site was listed on the National Priorities List in September 1983. Organic solvents and paint residues were dumped around a trench on the property. Cleanup efforts at Bog Creek have included removing and treating waste from the pond and bog, as well as covering the pond and bog. Methods used for treatment have included on-site incineration and a pump and treat system.

BRIDGEPORT RENTAL & OIL SERVICES (BROS) is a 30-acre site located in Logan Township, New Jersey, on the NPL which consisted of a tank farm (removed prior to 1989) and a 12.7-acre waste oil and waste water lagoon. Remediation at the site consists of removal and disposal of oily waste and sediment/sludge via on-site incineration; removal and disposal of contaminated water via an on-site treatment system; drum excavation and on-site disposal; and maintenance pumping to prevent further spread of contaminated plume and the capture of any contaminants that may escape during lagoon excavation. Remediation of the residual wells involves a water supply pipeline to contaminated wells from an existing pump station in the Village of Bridgeport.

CHEROKEE COUNTY, located in Galena County, Kansas in the Kansas portion of the Tri-State Mining District, contains six subsites. The most obvious remains of the mining activity at the subsite are large areas covered by mine and mill wastes, water-filled subsidence craters, and open mine shafts. The shallow groundwater aquifer and the surface water are contaminated with high concentration of metals. Also contaminated, beyond the primary and secondary maximum contamination levels of the Safe Drinking Water Act, are the private shallow aquifer wells. The Galena subsite, within the Cherokee County site, is characterized by surface mining waste features that impact the quality of the shallow groundwater aquifer. Remedial actions include (alternate water supply) the collection of water from the aquifer through existing wells with subsequent distribution of that water through a pipeline network to 418 houses, businesses, and farms outside of the Galena municipal water system The remedy includes construction and equipment necessary to set up a water supply to this area. Also included in the remedial action are: the removal, consolidation, and onsite placement in mine pits, shafts, and subsidences of surface mine wastes; diversion and channelization of surface streams with recontouring and vegetation of land surface; and investigation of deep aquifer quality followed by plugging all abandoned and inactive wells and rehabilitating active wells, if necessary.

DURANGO UMTRA SITE is one of several Department of Energy sites in the Uranium Mill Tailings Remedial Action Program, which were contaminated as a result of the production of uranium for the U.S. national defense program. The former Durango uranium processing site is located just outside the city limits of Durango in southwest Colorado. Two tailings piles were located on the 147-acre site. Approximately 1.2 million cubic yards of contaminated material was transported to an isolated disposal site in Bodo Canyon, Colorado. Remedial action was completed in May 1991. Groundwater cleanup has not yet occurred, but is expected to use a natural flushing groundwater compliance strategy.

SACRAMENTO ARMY DEPOT, a U.S. Department of the Army site was added to the National Priorities List in August 1987. Located in Sacramento, California, the site is approximately 7 miles southeast of the city's business district. The Depot, established in 1945, was used to store, issue, and maintain electronic supplies and commodities. The site consists of the following contaminated areas, each considered its own site: the Burn Pits, Oxidation Lagoons, Underground Storage Tanks, and groundwater. Technologies which have been or are being used for site remediation are soil vapor extraction, solidification, ventilation, tank removal, and groundwater treatment.

GRAND JUNCTION UMTRA SITE is one of several Department of Energy sites in the Uranium Mill Tailings Remedial Action Program, which were contaminated as a result of the production of uranium for the U.S. national defense program. The former Grand Junction millsite is a 114-acre site in Mesa County, Colorado, located in an industrial area of the city of Grand Junction. The DOE Environmental Management Program is responsible for cleaning up surface and ground water contamination at the UMTRA sites. Approximately 4.1 million cubic yards of contaminated materials were removed from the site by truck and rail, and transported 17 miles to the Cheney disposal cell. One building which remained on the site required D&D. Cleanup of the surface contamination and site restoration were complete in August 1994. Groundwater cleanup has not yet occurred, but is expected to use a natural flushing groundwater compliance strategy.

HOLLINGSWORTH SOLDERLESS TERMINAL COMPANY, located in Fort Lauderdale, Florida, was placed on the NPL in October 1981. This is the only non-Davis-Bacon site and the only non-union site in the data base. Hollingsworth consists of two buildings (Plant 1 and Plant 2), one a manufacturing plant which generated and discharged contaminants; the other an assembly and storage facility. Some of the wells which are located near Hollingsworth and are part of the City of Fort Lauderdale's primary water supply have been contaminated with VOCs. Remediation work includes excavation, aeration, and replacement on site of VOCs at the east drainfield of Plant 1 and recovery of contaminated groundwater, treatment, and reinjection into the aquifer.

K-25 GASEOUS DIFFUSION PLANT (OAK RIDGE RESERVATION) is a Department of Energy site located in Oak Ridge Tennessee and on the NPL. It occupies a 1500-acre area. At its inception, the K-25 Site was used to enrich uranium hexafloride for fuel for commercial reactors and for defense purposes. The site was shut down in 1987, as the demand for enriched uranium decreased. Currently, the site is most recognized as the location of the Toxic Substances Control Act (TSCA) Incinerator which destroys mixed wastes. The site also houses operating waste treatment and storage facilities, and environmental restoration and waste management organizations. Parts of the site have been targeted for D&D.

KEM-PEST LABORATORIES is a pesticide manufacturing company located on 6-acres in Cape Giradeau, Missouri. The site, which is listed on the NPL, contained a concrete block building which housed the Kem-Pest pesticide formulation operation; six storage tanks which contained solvents and oil; and the lagoon, in which the sewage and plant waste were disposed. Cleanup of the site involved the excavation of more than 4,050 cubic yards of contaminated soil and sediment, which was disposed of at an off-site land disposal facility in compliance with RCRA.

LIPARI LANDFILL, ranked number one when it was placed on the National Priorities List in 1983. It is a 15-acre site, of which six acres were actually used for landfilling, located in Mantua Township, Gloucester County, New Jersey. Lipari was treated as a typical landfill using encapsulation and slurry walls to contain the hazardous waste. A treatment plant was built on-site for the remediation of contaminated groundwater.

LONE PINE LANDFILL, a 45-acre landfill located in Monmouth County, New Jersey accepted a wide variety of wastes, including over 17,000 drums containing chemical wastes, sewage, household, commercial, municipal, and industrial wastes. The site is listed on the National Priorities List. Lone Pine was treated as a typical landfill, installing an impermeable landfill cap, a methane gas venting system, installation of a slurry wall, and a groundwater/leachate collection and treatment system. Off-site contamination was treated by installing extracting wells and with on-site treatment of the extracted groundwater.

MOYER LANDFILL, a 45-acre landfill located in Montgomery County, Pennsylvania accepted a variety of solid and liquid hazardous wastes while still in operation. Cleanup at the NPL site entailed installation of a leachate collection system and capping the landfill, and ground water monitoring.

NEW LYME LANDFILL, located in Ashtabula, Ohio, and on the NPL, occupies approximately 40-acres of a 100-acre tract. The landfill received household, industrial, commercial, and institutional wastes and construction and demolition debris. Cleanup at New Lyme has consisted of constructing a RCRA cap over the landfill including extraction/containment wells around the perimeter of landfill to dewater landfill and eliminate leachate production; and constructing and operating an extraction and treatment plant.

PADUCAH GASEOUS DIFFUSION PLANT, is an active Department of Energy plant which produces enriched uranium to be used as fuel for commercial reactors. As a result of this process, the Plant has both on-site and off-site contamination. Cleanup at the site consists, in part, of containing a groundwater plume from entrance into the Ohio River. The site was added to the National Priorities List in May 1994. Methods of remediation include groundwater extraction and treatment at two locations.

RIFLE UMTRA SITE, is one of several Department of Energy sites in the Uranium Mill Tailings Remedial Action Program, which were contaminated as a result of the production of uranium for the U.S. national defense program. The two inactive uranium processing sites at Rifle are located in the Colorado River Valley near the City of Rifle. The two sites are approximately two miles apart and are referred to as the Old Rifle and New Rifle sites. Together, the two tailings piles covered approximately 46-acres of land. The New Rifle site pile rose to 33 feet in height. Approximately 3.6 million cubic yards of contaminated materials are to be transported to the Estes Gulch disposal cell. Remedial action is expected to be completed during 1996. Surveillance and maintenance of the disposal cell will be conducted after the remedial action is complete. Groundwater cleanup has not yet occurred, but is expected to use a natural flushing groundwater compliance strategy.

SHIPROCK UMTRA SITE, is one of several Department of Energy sites in the Uranium Mill Tailings Remedial Action Program, which were contaminated as a result of the production of uranium for the U.S. national defense program. The former Shiprock site is located on a 230-acre tract on Navajo Nation land, adjacent to the town of Shiprock. Two piles of tailings covered approximately 72-acres. The site also included the former raffinate pond area and a few buildings. Surface remediation was completed in November 1986 and the source of contamination stabilized. Approximately 2.8 million cubic yards of residual radioactive material was consolidated and placed in a controlled, engineered disposal cell. Residual milling related contaminated groundwater remains and is expected to assume a natural flushing groundwater compliance strategy.

SOUTH TACOMA CHANNEL-WELL 12A, located in Tacoma, Washington, was one of thirteen wells used by the City to meet peak summer and emergency water demands. After discovering that the well was contaminated with chlorinated organic solvents, the well was removed from service. Cleanup consists of extraction and treatment of groundwater, and the excavation and movement of contaminated soils to a RCRA-permitted landfill.

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Appendix III

TABLES REFERRED TO IN TEXT

TABLE A
Important Details About 18 Hazardous Waste Sites

DETAILS	California	Colorado			Florida	Kansas	Kentucky	Louisiana
	CASAAD	Durango	Grand Junction	Rifle	Hollingsworth	Cherokee County	Paducah	Bonfouca
# Entries	227	4,811	686	10,150	62	1,418	1,029	9,409
# Months Payroll	15	20	5	68	18	41	13	28
Total Gross Pay	$201,887	$2,505,794	$459,867	$6,749,486	$38,711	$547,257	$464,339	$5,173,534
Average Gross Pay/Month	$13,459	12,529	$91,973	$99,257	$1,817	$13,348	$35,718	$184,769
Total Standard Hours	5,148	147,237	22,434	334,093	1,232	38,066	24,257	266,459
Average Standard Hours/Month	343	7,362	4,487	4,913	68	928	1,865	9,516
Total Overtime Hours	1,124	6,944	1,853	76,850	393	4,282	2,419	63,995
Average Overtime Hours/Month	75	347	371	1,130	22	104	186	2,286
Total Hours	6,272	154,181	24,287	410,944	1,624	42,348	26,677	330,455
Overtime as % of Total hours	18%	5%	8%	19%	24%	10%	9%	19%
Average Total Hours/Month	418	7,709	4,857	6,043	90	1,033	2,052	11,802
Average Hourly Rate	$23.85	$15.67	$12.66	$15.18	$9.49	$12.05	$18.81	$13.93

TABLE A, Continued
Important Details About 18 Hazardous Waste Sites

DETAILS	Missouri	New Jersey				New Mexico	Ohio	Pennsylvania	Tennessee	Washington	TOTALS
	Kem-Pest	Bog Creek	BROS	Lipari	Lone Pine	Shiprock	New Lyme	Moyer	K-25	Tacoma	
# Entries	114	2,828	13,995	4,629	20,859	4,360	3,817	1,070	1,844	459	81,767
# Months Payroll	10	18	54	29	31	30	28	15	17	15	455
Total Gross Pay	$82,282	$2,222,489	$14,564,763	$4,052,419	0	$1,132,310	$2,789,360	$1,142,272	$705,447	$455,973	$43,288,190
Average Gross Pay/Month	$8,228	$123,472	$269,718	$139,739	*	$37,744	$99,620	$76,151	$42,197	$30,398	$95,152
Total Standard Hours	3,464	92,347	533,399	158,163	*	77,119	126,318	32,449	43,557	14,665	1,920,407
Average Standard Hours/Month	346	5,130	9,867	5,454	*	2,571	4,511	2,163	2,562	978	4,221
Total Overtime Hours	1,016	25,428	123,073	11,810	*	1,268	22,486	7,680	7,000	3,587	361,208
Average Overtime Hours/Month	102	1,413	2,278	407	0	42	803	512	412	239	794
Total Hours	4,480	117,775	656,472	169,974	0	78,387	148,804	40,129	50,556	18,252	2,281,617

Overtime as % of Total hours	23%	22%	19%	7%	*	2%	15%	19%	14%	20%	16%
Average Total Hours/Month	448	6,543	12,145	5,861	0	2,613	5,314	2,675	2,974	1217	5,015
Average Hourly Rate	$15.55	$32.50	$20.23	$20.69	*	$12.82	$17.41	$18.36	$14.70	$22.55	$18.40

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

TABLE B
Categories of Site Types or Activities at Sites Studied

Categories (1)	Bog Creek	Bayou Bonfouca	BROS	Cherokee/Galena	Durango	Grand Junction	Hollins.	Kem-Pest
Landfill								
Surface Impoundments	X		X					
Wellfield	X						X	
Leaking Container			X					
Asbestos								
Radiological Tailings					X	X		
Chemical Manufacturing		X						X
Electrical								
Wood Preserving								
Waste Oil			X					
Manufacturing							X	
Plating								
Metal Working								
Drum Recycling								
Mining				X	X	X		
TNT Processing								

TABLE B, Continued

Categories (1)	Lipari	Lone Pine	Moyer	New Lyme	Paducah	Rifle	SAAD	Shiprock	Tacoma	K-15
Landfill	X	X	X	X						
Surface Impoundments										
Wellfield										
Leaking Container							X			

Asbestos										
Radiological Tailings					X	X		X		
Chemical Manufacturing									X	X
Electrical							X			
Wood Preserving										
Waste Oil										
Manufacturing							X			
Plating										X
Metal Working							X			
Drum Recycling										
Mining						X		X		
TNT Processing										

Source: Ruth Rutenberg & Associated, Inc. Data Base.

Key:

SAAD - Sacramento Army
Depot Hollins. - Hollingsworth

(1) Categories as defined by E.W. Colglazier, T. Cox, and K. Davis, University of Tennessee, Waste Management Research and Education Institute, Estimation of Resource Requirements for NPL Sites, December 1991.

TABLE C
Remedial Action Categories Used for Sites Studied

Remedy (1)	Bog Creek	Bayou Bonfouca	BROS	Cherokee/ Galena	Grand Junction	Hollings-worth	Kem-Pest	Lipari	Lone Pine	Moyer	New Lyme	Paducah	Rifle	SAAD	Shiprock	Tacoma	K-15
Institutional Controls				X			X									X	X
Containment		X						X	X	X	X						X
Water Collection/Treatment/ Discharge	X	X				X				X	X	X		X		X	
Soil/Sediment Removal, Low Intensity Treatment								X						X			X
Soil Sediment Removal, High Intensity Treatment	X	X	X														
In Situ Treatment						X		X						X			

Soil/Sediment Removal and Landfilling				X	X					X	X		X		X	X	X
Water Collection/Discharge to Existing Facility																	

Source: Ruth Rutenberg & Associates, Inc. Data Base.

Key:

SAAD - Sacramento Army Depot

(1) Remedial Action Categories as defined by E.W. Colglazier, T. Cox, and K. Davis, University of Tennessee, Waste Management Research and Education Institute, Estimation of Resource Requirements for NPL Sites, December 1991.

TABLE D
Gross Pay by Predominant Category at 17 Sites

CATEGORY	California	Colorado			Florida	Kansas	Kentucky	Louisiana
	SAAD	Durango	Grand Junction	Rifle	Holli.	Cherokee County	Paducah	Bonfouca
Asbestos	$5,271	-	-	-	-	-	-	-
Carpenter	-	-	-	$68,301	-	$4,920	$89,496	$238,363
Cement	-	-	-	$13,986	-	-	$9,023	$50,693
Driver	$294	$744,370	$192,333	$1,968,882	-	$263	$7,009	$84,284
Electrician	$1,959	$354	-	$73,273	-	$15,003	$30,526	$202,898
Iron Worker	-	-	-	$1,638	-	$9,639	$64,813	$65,349
Laborer	$90,953	$68,934	$16,024	$1,525,712	$27,283	$189,817	$87,173	$539,944
Mechanic	-	$186,542	$42,601	$407,538	-	-	-	$615
Operator	$80,939	$1,041,982	$35,065	$2,375,080	$4,710	$154,043	$67,744	$963,013
Plumber/Pipe fitter	-	-	-	$281	-	$2,694	$30,268	$225,948
Other	$22,471	$463,612	$173,842	$314,795	$6,717	$170,880	$78,289	$2,802,427
Total:	$201,887	$2,505,794	$459,865	$6,749,486	$38,710	$547,259	$464,341	$5,173,534

TABLE D, Continued

CATEGORY	Missouri	New Jersey			New Mexico	Ohio	Pennsylvania	Tennessee	Washington	TOTALS
	Kem-Pest	Bog Creek	BROS	Lipari	Ship-Rock	New Lyme	Moyer	K-25	Tacoma	
Asbestos	-	-	$32,116	$24,212	-	-	-	$39,323	-	$100,922
Carpenter	$2,811	$194,279	$617,690	$211,802	$1,655	$18,649	-	$74,708	$64,203	$1,586,877
Cement	-	$12,832	-	$86,599	$824	$6,212	-	$737	-	$180,006
Driver	$1,266	$6,866	$683,779	$59,588	$114,402	$474,667	-	$1,653	$1,159	$4,340,815
Electrician	$328	$229,277	$437,646	$611,054	-	$4,449	-	$11,435	$91,394	$1,709,506
Iron Worker	-	$34,962	$274,820	$306,722	-	$62,970	-	$3,204	-	$824,117

Laborer	$45,713	$272,717	$3,055,600	$552,060	$239,782	$558,505	$481,340	$306,509	$118,951	$8,177,017
Mechanic	-	$2,404	$1,035,394	$3,630	$1,339	$4,068	$760	$1,958	-	$1,686,849
Operator	$6,732	$494,809	$6,135,712	$423,524	$668,196	$955,352	$567,082	$33,732	$8,174	$14,015,889
Plumber/Pipe Fitter	-	$173,715	$217,383	$1,109,419	-	$18,999	-	$55,004	$6,145	$1,839,856
Other	$25,432	$800,629	$2,074,623	$663,811	$106,112	$685,489	$93,090	$177,184	$165,947	$8,825,350
Total:	$82,282	$2,222,490	$14,564,763	$4,052,421	$1,132,310	$2,789,360	$1,142,272	$705,447	$455,973	$43,288,194

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

Note: For more details about "categories" check individual tables.

Key:

SAAD - Sacramento Army Depot
Holli. - Hollingsworth

TABLE E
Percent of Gross Pay at 11 NPL Sites, by Predominant Category

CATEGORY	California	Florida	Kentucky	Louisiana	Missouri	New Jersey			Ohio	Pennsylvania	Tennessee	
	CASAAD	Holli.	Paducah	Bonfouca	Kem-Pest	Bog Creek	BROS	Lipari	New Lyme	Moyer	K-25	TOTAL
Carpenter	-	-	19%	5%	3%	8%	4%	5%	1%	-	11%	5%
Cement	-	-	2%	1%	-	1%	-	2%	0%	-	0%	1%
Driver	-	-	1%	2%	2%	-	5%	1%	14%	-	0%	4%
Electrician	1%	-	4%	4%	0%	10%	1%	15%	0%	-	2%	5%
Iron Worker	-		14%	1%	-	2%	2%	8%	2%	-	0%	3%
Laborer	45%	70%[1]	19%	10%	56%	12%	21%	14%	20%	42%	43%	19%
Mechanic	-	-	-	0%	-	0%	7%	0%	0%	0%	0%	3%
Operator	40%	12%	16%	19%	8%	27%	42%	10%	34%	50%	5%	31%
Plumber/Pipe Fitter	-		6%	4%	-	8%	2%	27%	1%	-	8%	6%
Other	13%	17%	16%	54%	31%	30%	16%	16%	25%	8%	31%	24%
TOTAL:[2]	100%	99%	99%	100%	100%	98%	100%	98%	99%	100%	100%	101%

Source: Ruth Ruttenberg & Associates, Inc. Data base.

(1) Laborer category in this instance is primarily industrial laborer rather than construction laborer.
(2) Total percent is overall for all crafts, even those not included in this table. Bog Creek total percent is high due to issues of overtime and call pay.

TABLE F
Average Hourly Earnings by Predominant Category of Worker at 17 Sites

Categories	California	Colorado			Florida	Kansas	Kentucky	Louisiana
	CASAAD	Durango	Grand Junction	Rifle	Hollingsworth	Cherokee County	Paducah	Bonfouca
Asbestos	$10.69	-	-	-	-	-	-	-
Carpenter	-	-	-	$16.38	-	$15.12	$19.81	$16.60
Cement	-	-	-	$17.66	-	-	$19.17	$15.58
Driver	$26.72	$16.27	$12.40	$16.60	-	$7.52	$16.53	$13.89
Electrician	$32.74	$18.14	-	$20.79	-	$17.94	$21.99	$17.13
Iron Worker	-	-	-	$17.60	-	$18.00	$22.08	$14.23
Laborer	$20.09	$12.45	$10.85	$13.40	$9.32	$9.62	$15.32	$9.50

Mechanic	-	$16.62	$13.81	$17.45	-	-	-	-
Operator	$32.35	$16.10	$13.66	$15.11	$10.33	$12.88	$19.76	$16.08
Plumber/Pipe fitter	-	-	-	$20.10	-	$20.09	$23.00	$19.06
Average (1)	$23.85	$15.67	$12.66	$15.18	$9.49	$12.05	$18.81	$13.93

TABLE F, Continued

Categories	Missouri	New Jersey			New Mexico	Ohio	Pennsylvania	Tennessee	Washington	Average Hourly rate
	Kem-Pest	Bog Creek	BROS	Lipari	Shiprock	New Lyme	Moyer	K-25	Tacoma	
Asbestos	-	-	$24.81	$22.15	-	-	-	$14.93	-	$19.58
Carpenter	$20.47	$25.05	$24.70	$23.21	$16.19	$18.86	-	$15.79	$24.43	$22.14
Cement	-	$21.64	-	$22.26	$14.21	$19.65	-	$16.37	-	$19.68
Driver	$18.48	$14.30	$18.52	$17.76	$13.51	$15.01	-	$10.87	$19.61	$16.36
Electrician	$19.20	$26.05	$21.15	$22.20	-	$20.53	-	$15.71	$25.87	$21.90
Iron Worker	-	$24.02	$22.02	$21.72	-	$19.83	-	$16.56	-	$21.13
Laborer	$15.15	$24.49	$17.87	$16.60	$10.80	$16.26	$17.57	$12.36	$19.47	$15.80
Mechanic	-	$16.81	$17.31	$23.52	$14.22	$20.50	$23.25	$17.73	-	$17.19
Operator	$16.25	$40.65	$24.63	$22.21	$14.07	$19.04	$21.20	$15.58	$19.16	$21.09
Plumber/Pipe Fitter	-	$25.95	$22.47	$20.83	-	$20.73	-	$17.77	$21.30	$21.23
Average (1)	$15.55	$32.50	$20.23	$20.69	$12.82	$17.41	$18.36	$14.70	$22.55	$18.40

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

Key:

CASAAD - Sacramento Army Depot
Hollingsworth - Hollingsworth Solderless Terminal Company
BROS - Bridgeport Rental & Oil Services

(1) Average is overall for all crafts,even those not included in this table. Bog Creek average is especially high due to issues of overtime and call pay.

TABLE G
Site Categories and Activities[1] at 12 NPL Sites

Categories	California	Florida	Kentucky	Louisiana	Missouri	New Jersey				Ohio	Pennsylvania	Tennessee
	SAAD	Hollings.	Paducah	Bonfouca	Kem-Pest	Bog Creek	BROS	Lipari	Lone Pine	New Lyme	Moyer	K-25
Landfill								X	X	X	X	
Surface Impoundments				X		X	X					
Wellfield						X						
Leaking Container	X						X					
Asbestos												

Radiological Tailings			X										
Chemical Manufacturing					X								X
Electrical	X												
Wood Preserving													
Waste Oil							X						
Manufacturing	X	X											
Plating													X
Metal Working	X												
Drum Recycling													
Mining													
TNT Processing													

Source: Ruth Ruttenberg & Associates, Inc. Data base.

Key:

Hollingsworth. - Hollingsworth Solderless
Terminal Company SAAD - Sacramento Army Depot

(1) Categories as defined by E.W. Colglazier, T. Cox, and K. Davis, Estimation of Resource Requirements for NPL Sites, Waste Management Research and Education Institute, University of Tennessee, December 1991.

TABLE H
Gross Pay by Predominant Category at 11 NPL Sites[1]

CATEGORY	California	Florida	Kentucky	Louisiana	Missouri	New Jersey			OHIO	Pennsylvania	Tennessee	Total
	SAAD	Holli.	Paducah	Bonfouca	Kem-Pest	Bog Creek	BROS	Lipari	New Lyme	Moyer	K-25	
Asbestos	$5,271	-	-	-	-	-	$32,116	$24,212	-	-	$39,323	$100,922
Carpenter	-	-	$89,496	$238,363	$2,811	$194,279	$617,690	$211,802	$18,649	-	$74,708	$1,447,798
Cement	-	-	$9,023	$50,693	-	$12,832	-	$86,599	$6,212	-	$737	$166,096
Driver	$294	-	$7,009	$84,284	$1,266	$6,866	$683,779	$59,588	$474,667	-	$1,653	$1,319,406

Electrician	$1,959	-	$30,526	$202,898	$328	$229,277	$437,646	$611,054	$4,449	-	$11,435	$1,529,572
Iron Worker	-	-	$64,813	$65,349	-	$34,962	$274,820	$306,722	$62,970	-	$3,204	$812,840
Laborer	$90,953	$27,283	$87,173	$539,944	$45,713	$272,717	$3,055,600	$552,060	$558,505	$481,340	$306,509	$6,017,797
Mechanic	-	-	-	$615	-	$2,404	$1,035,394	$3,630	$4,068	$760	$1,958	$1,048,829
Operator	$80,939	$4,710	$67,744	$963,013	$6,732	$494,809	$6,135,712	$423,524	$955,352	$567,082	$33,732	$9,733,349
Plumber/Pipe Fitter	-	-	$30,268	$225,948	-	$173,715	$217,383	$1,109,419	$18,999	-	$55,004	$1,830,736
Other	$22,471	$6,717	$78,289	$2,802,427	$25,432	$800,629	$2,074,623	$663,811	$685,489	$93,090	$177,184	$7,430,162
Total:	$201,887	$38,710	$464,341	$5,173,534	$82,282	$2,222,490	$14,564,763	$4,052,421	$2,789,360	$1,142,272	$705,447	$31,437,507

Source: Ruth Ruttenberg & Associates, Inc. Data base.

(1) For a portion of each site.

TABLE J
O&M Costs Associated with Remediation

State	Site	Technology	Capital Cost (1000s)	Annual Operating Cost (1000s)	1 yr Operating as % of Capital
Arkansas	Evelson AFB	Bioremediation	$758	$177	23%
California	McClellan AFB	Pump & Treat	$4,000	$1,240	31%
Colorado	Lowry AFB	Bioremediation/biovent (UST)	$29	$33	114%
Colorado	Lowry AFB	Bioremediation-land treatment (UST)	$104	$76	73%
Michigan	Amoco Petrol. Pipeline	Groundwater Remed	$672	$475	71%
Minnesota	Twin Cities Army Munition Plant	Pump & Treat	$8,000	$589	7%
Missouri	Kansas City Plant (DOE)	Pump & Treat	$1,383	$355	26%
South Carolina	Savannah River (D0E)	In Situ air stripping	$259	$220	85%
South Carolina	Savannah River (DOE)	Pump & Treat	$4,103	$149	4%
Utah	Amcor Precast	Groundwater, spraying	$157	$63	40%
Utah	Hill AFB	Bioremediation	$115	$24	21%
Virginia	Langley AFB	Pump & Treat	$570	$217	38%
Virginia	Langley AFB	Pump & Treat	$570	$143	25%

Sources: Doty Carolyn, Amelia Crotwell, and Curtis Travis, Cost Growth for Treatment Technologies at NPL Sites, December 1991; EPA and Member Agencies of the Federal Remediation Technologies Roundtable, Remediation Case Studies: Groundwater Treatment, March 1995; EPA and Member Agencies of the Federal Remediation Technologies Roundtable, Abstracts of Remediation Case Studies, March 1995; U.S. DOE, Estimating the Cold War Mortgage: The 1995 Baseline Environmental Management Report. March 1995.

TABLE K
Average Hourly Earnings by Category at Eight Removal Sites

DETAILS	REGION 3	REGION 4			REGION 5		REGION 7		TOTAL
	Martin	**Anderson**	**Carolina Creosote II**	**CHEMET**	**Bernard Neal**	**Superior Polishing**	**Bannister**	**Turner Seed**	
Chemist/Organic	-	$46.66	-	$46.66	-	-	-	$48.00	$47.11
Equipment Operator	-	$35.58	$45.20	$35.58	$39.27	$36.04	$34.10	$34.10	$37.12
Field Clerk/Typist	$28.00	$29.96	-	$29.96	$32.41	$25.20	$27.02	$27.02	$28.51
Foreman	-	-	-	$34.44	$34.73	$37.16	$39.18	$39.18	$36.94
Health & Safety	-	$39.37	-	$39.37	-	-	-	-	$39.37
Industrial Hygienist Safety	-	-	-	-	-	-	$38.02	$38.02	$38.02
Laborer	$24.00	-	$34.03	$30.82	$27.78	$29.28	$28.21	$28.21	$28.90
Lab Technician			-	$26.93	-	-	-	-	$26.93
Level B	-	-	-	$6.47	-	-	$3.38	$3.38	$4.41
Level C	-	-	-	-	-	-	$2.86	$2.83	$2.85
Program Auditor			-	$40.91	-	-	-	-	$40.91
Program Manager	-	$55.86	-	$72.40	-	-	-	-	$64.13
Response Manager	$45.00	$55.86	$66.86	$55.86	$51.84	$48.43	$54.61	$61.36	$54.98
Secretary	-	$32.81	-	$32.81	-	-	-	-	$32.81
Site & Safety			-	-	-	$61.94	-	-	$61.94
T&D Coordinator			-	$40.15	$34.73	$51.90	-	-	$42.26
Truck Driver	-	-	-	$34.62	-	$32.94	$33.08	$33.08	$33.43
AVERAGE HOURLY RATE:	$32.33	$43.55	$42.64	$36.03	$36.79	$40.36	$31.53	$31.52	$36.51

Source: U.S. EPA, Removal Cost Management System and Ruth Ruttenberg & Associates, Inc.

TABLE L
Percent of Total Hours by Predominant Category at Eight Removal Sites

CATEGORIES	Martin	Anderson	Carolina Creosote II	Chemet	Bernard Neal	Superior Polishing	Bannister	Turner Seed	TOTAL
Operator	-	21%	73%	28%	17%	24%	6%	0%	0%
Response Manager	48%	18%	21%	16%	19%	13%	25%	0%	0%
Laborer	38%	-	6%	37%	25%	21%	27%	0%	0%
Former	-	-	-	2%	16%	13%	10%	0%	0%
Truck Driver	-	-	-	1%	-	8%	1%	0%	1%
Other	13%	45%	0%	17%	22%	22%	31%	0%	26%

TOTAL	100%	100%	100%	100%	100%	100%	100%	0%	101%

Source: U.S. EPA, Removal Cost Management System and Ruth Ruttenberg & Associates, Inc.

TABLE M
Total Hours by Predominant Category at Eight Removal Sites

CATEGORIES	Martin	Anderson	Carolina Creosote II	Chemet	Bernard Neal	Superior Polishing	Bannister	Turner Seed	TOTAL
Operator	-	57	370	1,939	245	495	29	131	3,266
Response Manager	47	92	107	1,093	279	284	123	528	2,553
Laborer	37	-	28	2,533	367	438	133	2,152	5,688
Foreman	-	-	-	132	230	265	48	463	1,138
Truck Driver	-	-	-	45	-	160	6	24	235
Other	13	122	-	1,187	319	463	149	2,249	4,502
Total	97	271	505	6,929	1,440	2,105	488	5,547	17,382

Source: U.S. EPA, Removal Cost Management System and Ruth Ruttenberg & Associates, Inc.

TABLE N
Labor Mix at Six DOE Environmental Restoration Sites by Percent of Gross Pay

CRAFT	Durango UMTRA	Grand Junction UMTRA	K-25	Paducah	Rifle UMTRA	Shiprock UMTRA
Asbestos	-	-	1%	-	-	-
Bricklayer	-	-	1%	-	-	-
Carpenter	-	-	11%	19%	1%	-
Cement Mason	-	-	-	2%	-	-
Driver	30%	42%	-	1%	29%	11%
Electrician	-	-	2%	7%	1%	-
Iron Worker	-	-	-	14%	-	-
Laborer	3%	3%	43%	19%	23%	23%
Mechanic	7%	9%	0%	-	6%	0%
Operator	42%	8%	5%	15%	35%	64%
Plumber	-	-	-	4%	-	-
Pipe Fitter	-	-	8%	2%	-	-
Roofer	-	-	5%	-	-	-

Sheet Metal	-	-	2%	-	-	-
Other	18%	38%	22%	17%	5%	2%
TOTAL	100%	100%	100%	100%	100%	100%

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

TABLE O
Average Hourly Earnings for Predominant Categories at Six DOE Sites

CATEGORIES	Colorado		Tennesse	Kentucky	Colorado	New Mexico
	Durango	Grand Junction	K-25	Paducah	Rifle	Shiprock
Asbestos	-	-	$14.93	-	-	-
Carpenter	-	-	$15.79	$19.81	$16.38	$16.19
Cement	-	-	$16.37	$19.17	$17.66	$14.21
Driver	$16.27	$12.40	$10.87	$16.53	$16.60	$13.51
Electrician	$18.14	-	$15.71	$21.99	$20.79	-
Iron Worker	-	-	$16.56	$22.08	$17.60	-
Laborer	$12.45	$10.85	$12.36	$15.32	$13.40	$10.80
Mechanic	$16.62	$13.81	$17.73	-	$17.45	$14.22
Operator	$16.10	$13.66	$15.58	$19.76	$15.11	$14.07
Plumber/Pipe fitter	-	-	$17.77	$23.00	$20.10	-
Average	$15.67	$12.66	$14.70	$18.81	$15.18	$12.82

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

TABLE P
Percent of Gross Pay by Category at 4 UMTRA Sites

CATEGORY	COLORADO			NM	TOTAL
	Durango	Grand Junction	Rifle	Shiprock	
Carpenter	-	-	1%	-	0%
Cement	-	-	-	-	0%
Driver	30%	42%	29%	11%	11%
Electrician	-	-	1%	-	0%
Iron Worker	-	-	-	-	0%
Laborer	3%	3%	23%	23%	23%
Mechanic	7%	9%	6%	0%	0%
Operator	42%	8%	35%	64%	65%
Other	18%	38%	3%	1%	1%
TOTAL:	100%	100%	98%	99%	101%

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

TABLE Q
Labor Mix at 4 UMTRA Sites, Based on Gross Pay from Certified Payrolls

CRAFT	PERCENT	CRAFT	PERCENT
Operators	38%	Drivers	28%
Laborers	17%	Mechanics	6%
Electricians	1%	Other Crafts	10%
Carpenters	1%	TOTAL	101%

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

TABLE R
Average Hourly Earnings at Four UMTRA Sites

CATEGORIES	COLORADO			NEW MEXICO	AVERAGE HOURLY EARNING
	Durango	Grand Junction	Rifle	Shiprock	
Carpenter	-	-	$16.38	$16.19	$16.38
Driver	$16.27	$12.40	$16.60	$13.51	$16.12
Electrician	$18.14	-	$20.79	-	$20.78
Laborer	$12.45	$10.85	$13.40	$10.80	$13.01
Mechanic	$16.62	$13.81	$17.45	$14.22	$16.96
Operator	$16.10	$13.66	$15.11	$14.07	$15.18
Average (1)	$15.67	$12.66	$15.18	$12.82	$14.94

Source: Ruth Ruttenberg and Associates, Inc. Data Base.

(1) Average is overall for all crafts, even those not included in this table. Bog Creek average is especially high dueto issues of overtime and call pay.

TABLE S
Predominant Remedies by Site

State	# Remedies Cited	On site Treatment		On Site Containment		Off Site Treatment		Off Site Containment		Population Protection		Site Security		Innovative Technology	
Alabama	41	2	5%	1	2%	37	90%	0	0%	0	0%	1	2%	0	0%
Alaska	39	18	36%	7	14%	15	30%	4	8%	3	6%	3	6%	0	0%
Arizona	30	7	26%	9	33%	1	4%	4	15%	0	0%	6	22%	0	0%
California	28	0	0%	0	0%	0	0%	0	0%	0	0%	28	100%	0	0%
Colorado	14	4	33%	2	17%	0	0%	2	17%	1	8%	1	8%	2	17%
Florida	53	18	45%	0	0%	3	8%	16	40%	1	3%	1	3%	1	3%
Illinois	426	25	10%	15	6%	7	3%	189	77%	4	2%	3	1%	1	0%
Indiana	38	2	6%	3	9%	9	27%	14	42%	2	6%	3	9%	0	0%
Kansas	111	81	76%	12	11%	0	0%	5	5%	4	4%	1	1%	3	3%
Louisiana	60	4	10%	9	22%	3	7%	22	54%	0	0%	3	7%	0	0%

Maine	44	10	21%	7	15%	11	23%	8	17%	7	15%	4	9%	0	0%
Maryland	233	16	10%	62	38%	0	0%	70	43%	1	1%	14	9%	0	0%
Massachusetts	640	24	6%	102	27%	0	0%	257	67%	0	0%	0	0%	0	0%
Minnesota	315	83	28%	114	38%	27	9%	45	15%	17	6%	10	3%	1	0%
Mississippi	66	13	27%	5	11%	3	6%	22	47%	1	2%	2	4%	1	2%
Missouri	83	7	13%	7	13%	2	4%	29	52%	0	0%	11	20%	0	0%
Montana	50	3	6%	12	24%	14	28%	14	28%	3	6%	4	8%	0	0%
Nevada	16	11	61%	1	6%	4	22%	2	11%	0	0%	0	0%	0	0%
New Jersey	2,258	37	3%	149	12%	42	3%	1017	79%	2	0%	35	3%	1	0%
New Mexico	19	1	7%	2	14%	2	14%	7	50%	1	7%	1	7%	0	0%
New York	270	22	14%	20	12%	4	2%	111	68%	2	1%	4	2%	0	0%
Ohio	12	6	40%	3	20%	4	27%	1	7%	0	0%	1	7%	0	0%
Oklahoma	66	2	6%	2	6%	0	0%	31	89%	0	0%	0	0%	0	0%
Pennsylvania	8	1	4%	3	11%	20	71%	0	0%	2	7%	2	7%	0	0%
Rhode Island	177	5	5%	0	5%	0	0%	86	95%	0	0%	0	0%	0	0%
South Carolina	54	4	8%	0	0%	14	29%	19	39%	0	0%	11	22%	1	2%
South Dakota	782	0	0%	0	0%	0	0%	391	100%	0	0%	0	0%	0	0%
Tennessee	93	7	13%	8	14%	1	2%	38	68%	0	0%	2	4%	0	0%
Texas	98	23	27%	9	10%	0	0%	12	14%	2	2%	40	47%	0	0%
Utah	25	2	10%	9	45%	1	5%	6	30%	0	0%	2	10%	0	0%
Washington	87	15	18%	24	28%	13	15%	15	18%	14	16%	4	5%	0	0%
TOTAL:	3,999	453	11%	597	15%	237	6%	2437	61%	67	2%	197	5%	11	-

Source: Kensington System, Inc.,"State and Territory System Documentation," August 1994.

TABLE T
Major Remedy in Use, by State

State[1]	Major Remedy By Site	%Site	Average State Cost (millions $)
Alabama	Off-Site Treatment	90%	7

Alaska	On site treatment	33%	95
Arizona	On site containment	33%	232
California	Site Security	100%	407
Colorado	On site treatment	33%	3,200
Florida	On site treatment	45%	467
Illinois	Off site containment	77%	167
Indiana	Off site containment	42%	168
Kansas	On site treatment	76%	84
Louisiana	Off site containment	54%	41
Maine	Off site treatment	23%	90
Maryland	Off site containment	43%	77
Massachusetts	Off site containment	67%	77
Minnesota	On site containment	38%	128
Mississippi	Off site containment	47%	n.a.
Missouri	Off site containment	52%	43
Montana	Off site containment	28%	253
Nebraska	Off site treatment	28%	n.a.
Nevada	On site treatment	61%	n.a.
New Jersey	Off site containment	79%	974
New Mexico	Off site containment	50%	681
Ohio	On site treatment	40%	n.a.
Oklahoma	Off site containment	89%	3R
Pennsylvania	Off site treatment	71%	305
Rhode Island	Off site containment	95%	n.a.
South Dakota	Off site containment	100%	n.a.

South Carolina	Off site containment	39%	201
Tennessee	Off site containment	68%	51
Texas	Site Security	47%	701
Utah	On site containment	45%	33
Washington	On site containment	28%	84

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

(1) No information for the following states: CT, DE, MI, NE, NC, OR, VA, WI.

TABLE U
Duration of State Response Actions in Months

States	# Sites	<12 months	12-23 months	24-35 months	36-47 months	48-59 months	60-71 months	71 months
Alabama	44	35	9	0	0	0	0	0
Alaska	33	28	4	1	0	0	0	0
Arizona	30	22	1	2	2	1	2	0
Colorado	3	3	0	0	0	0	0	0
Florida	24	6	7	3	1	1	2	4
Illinois	209	128	21	11	7	8	8	26
Indiana	15	10	2	1	2	0	0	0
Louisiana	23	5	2	6	7	1	1	1
Maine	34	12	6	5	5	3	1	2
Maryland	40	31	8	1	0	0	0	0
Massachusetts	391	169	118	46	22	10	13	13
Minnesota	80	39	13	14	9	2	0	3
Mississippi	24	3	5	3	11	0	0	2
Missouri	34	13	10	5	2	2	1	1
Nevada	7	4	2	0	1	0	0	0
New Jersey	4,440	3,389	537	208	141	77	36	52

New Mexico	7	5	2	0	0	0	0	0
New York	111	68	17	11	4	7	1	3
Oklahoma	7	5	1	0	0	0	0	1
Pennsylvania	25	16	9	0	0	0	0	0
Rhode Island	10	7	0	2	0	0	1	0
South Carolina	18	15	3	0	0	0	0	0
South Dakota	212	100	38	19	23	7	6	19
Tennessee	43	30	8	1	4	0	0	0
Texas	2	2	0	0	0	0	0	0
Utah	10	5	3	2	0	0	0	0
Washington	28	18	6	1	1	1	1	0
TOTAL:	5,904	4,168	832	342	242	120	73	127

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

TABLE V
State Data
Removal, Remedial, and Last Remedial Phase

Site	# sites	Removals				Remedial Actions									
		Ongoing		Complete		Active		No Further Action							
		#	% of Removal	#	% of Removal	#	% of Removal	#	% of Removal	No remedial action based on PA/SI or RI		All remedial action completed (1)		All remedial action completed	
Alaska	41	4	27%	11	73%	11	58%	8	42%	2	25%	3	38%	3	38%
Alabama	69	31	45%	38	55%	1	13%	7	88%	7	100%	0	0%	0	0%
Arizona	76	8	20%	33	80%	34	46%	40	54%	0	0%	7	18%	33	83%
California	1850	20	12%	152	88%	213	26%	600	74%	451	75%	24	4%	125	21%
Colorado	11	4	44%	5	56%	5	100%	0	100%	0	0%	0	0%	0	0%
Delaware	185	10	91%	1	9%	84	48%	91	52%	91	100%	0	0%	0	0%
Florida	36	15	42%	21	58%	13	36%	23	64%	2	9%	6	26%	15	65%
Illinois	906	553	73%	207	27%	651	78%	189	23%	2	1%	11	6%	176	93%

Indiana	79	27	60%	18	40%	25	93%	2	7%	0	0%	1	50%	1	50%
Kansas	183	62	93%	5	7%	179	98%	3	2%	1	33%	2	67%	0	0%
Louisiana	101	50	50%	5	50%	69	77%	21	23%	0	0%	2	10%	19	90%
Massachusetts	3089	2669	86%	420	14%	2553	83%	536	17%	157	29%	28	5%	351	65%
Maryland	378	4	13%	26	87%	166	44%	212	56%	211	100%	1	0%	0	0%
Maine	70	10	29%	25	71%	51	81%	12	19%	3	25%	7	58%	2	17%
Michigan	2662	1584	82%	343	18%	1584	60%	1078	41%	735	68%	29	3%	314	29%
Minnesota	414	11	26%	31	74%	293	73%	108	27%	56	52%	35	32%	17	16%
Missouri	44	0	0%	23	100%	11	53%	10	48%	0	0%	10	100%	0	0%
Mississippi	110	0	0%	17	100%	89	85%	16	15%	8	50%	5	31%	3	19%
Montana	214	27	51%	26	49%	169	96%	7	4%	3	43%	0	0%	4	57%
Nebraska	15	0	0%	0	0%	15	100%	0	0%	0	0%	0	0%	0	0%
New Jersey	5996	798	44%	1030	56%	1374	23%	4621	77%	3673	79%	23	1%	925	20%
New Mexico	58	1	13%	7	88%	49	98%	1	2%	1	100%	0	0%	0	0%
Nevada	34	0	0%	0	0%	24	71%	10	29%	1	10%	2	20%	7	70%
New York	556	33	13%	231	88%	442	80%	112	20%	85	76%	16	14%	11	10%
North Carolina	873	2	100%	0	0%	646	74%	225	26%	217	96%	5	2%	3	1%
Ohio	86	29	78%	8	22%	60	97%	2	3%	0	0%	2	100%	0	0%
Oklahoma	40	0	0%	32	100%	4	50%	4	50%	0	0%	3	75%	1	25%
Oregon	307	9	36%	16	64%	205	81%	49	19%	41	84%	1	2%	7	14%
Pennsylvania	41	13	35%	24	65%	9	100%	0	0%	0	0%	0	0%	0	0%
Rhode Island	97	1	1%	82	99%	13	93%	1	7%	0	0%	1	100%	0	0%
South Dakota	674	242	40%	372	61%	41	68%	19	32%	0	0%	0	0%	19	100%
South Carolina	42	3	16%	16	84%	19	79%	5	21%	1	20%	0	0%	4	80%
Tennessee	244	0	0%	40	100%	198	70%	7	3%	3	43%	0	0%	4	57%
Texas	200	39	72%	15	28%	151	94%	10	6%	0	0%	7	70%	3	30%
Utah	31	1	14%	6	86%	24	96%	1	4%	1	100%	0	0%	0	0%
Virginia	21	20	100%	0	0%	0	0%	1	100%	0	0%	0	0%	1	100%

Washington	1220	27	59%	19	41%	171	45%	210	55%	76	36%	29	14%	105	50%
Wisconsin	1849	0	0%	222	100%	1352	83%	275	17%	0	0%	0	0%	275	100%
TOTAL:	22902	6307	-	3527	-	10998	-	8516	-	5828	-	260	-	2428	-

Table V, Continued

Site	**Last Remedial Phase**							
	PA/SI		**RI/FS**		**RD**		**RA**	
Alaska	11	55%	0	0%	4	20%	5	25%
Alabama	0	0%	0	0%	1	100%	0	0%
Arizona	2	6%	23	74%	3	10%	3	10%
California	45	47%	32	34%	13	14%	5	5%
Colorado	0	0%	2	40%	3	60%	0	0%
Delaware	78	93%	5	6%	1	1%	0	0%
Florida	1	7%	4	27%	8	53%	2	20%
Illinois	1	0%	571	96%	18	3%	3	1%
Indiana	16	70%	7	30%	0	0%	0	0%
Kansas	87	49%	42	23%	21	12%	29	16%
Louisiana	55	83%	10	15%	1	2%	0	0%
Massachusetts	929	35%	1522	58%	64	2%	110	4%
Maryland	40	93%	3	7%	0	0%	0	0%
Maine	32	71%	9	20%	2	4%	2	4%
Michigan	0	0%	1701	99%	2	0%	10	1%
Minnesota	117	41%	95	33%	60	21%	16	6%
Missouri	1	10%	6	60%	3	30%	0	0%
Mississippi	25	28%	49	55%	4	4%	11	12%
Montana	132	77%	39	23%	0	0%	0	0%
Nebraska	15	100%	0	0%	0	0%	0	0%
New Jersey	546	49%	245	22%	267	24%	63	6%

New Mexico	34	69%	4	8%	11	22%	0	0%
Nevada	4	23%	5	23%	6	28%	6	28%
New York	342	78%	66	15%	12	3%	19	4%
North Carolina	635	98%	9	1%	3	0%	2	0%
Ohio	25	41%	31	51%	3	5%	2	3%
Oklahoma	0	0%	3	75%	1	25%	0	0%
Oregon	165	92%	13	7%	1	1%	1	1%
Pennsylvania	0	0%	9	100%	0	0%	0	0%
Rhode Island	2	20%	4	27%	6	40%	3	20%
South Dakota	0	0%	25	61%	9	22%	7	17%
South Carolina	6	38%	8	50%	1	6%	1	6%
Tennessee	153	77%	25	20%	14	7%	6	3%
Texas	56	33%	89	52%	13	8%	14	8%
Utah	3	14%	8	36%	8	36%	3	14%
Virginia	0	0%	0	0%	0	0%	0	0%
Washington	291	78%	60	16%	6	2%	15	4%
Wisconsin	36	20%	110	61%	2	1%	31	17%
TOTAL:	3885	-	4834	-	571	-	369	-

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

(1) Except Operations/Maintenance.

TABLE W
Remedies By States (1)
1. On-Site Treatment (2)

States	**A1:** Soil Aeration Technologies	**A2:** Bio-degradation	**A3:** Detonation	**A4:** Incineration with On-site Disposal of Residual	**A5:** Incineration with Off-Site Disposal of Residual	**A6:** pH Neutralization	**A7:** Component Separation	**A8:** Thermal Treatment with On-site Placement of Residual
Alabama	0	0	0	0	0	2	0	0
Alaska	7	6	0	1	0	0	1	0
Arizona	0	1	0	0	0	1	0	0

Colorado	1	0	0	0	0	1	0	0
Florida	1	0	0	1	2	0	0	0
Illinois	5	1	0	0	4	0	0	0
Indiana	0	0	0	0	0	0	0	0
Kansas	13	4	0	0	0	0	0	1
Louisiana	1	1	0	0	0	0	0	0
Maine	3	2	0	0	0	0	0	0
Maryland	0	0	1	0	0	0	0	1
Massachusetts	0	0	0	0	2	0	1	0
Minnesota	12	18	0	1	0	0	2	0
Mississippi	1	4	0	0	0	0	0	0
Missouri	1	0	0	0	0	0	0	0
Montana	0	0	0	0	0	1	0	1
Nevada	1	0	0	0	0	0	0	0
New Jersey	3	2	0	1	2	2	3	2
New Mexico	0	0	0	0	0	0	0	0
New York	2	0	0	1	0	0	0	0
Ohio	1	0	0	0	0	0	0	0
Oklahoma	0	1	0	0	0	1	0	0
Pennsylvania	0	0	1	0	0	0	0	0
Rhode Island	1	0	0	0	0	0	0	0
South Carolina	0	1	0	0	0	0	0	0
Tennessee	3	0	0	0	0	0	0	0
Utah	0	0	0	0	0	0	0	0
Washington	1	2	0	0	0	1	0	0
TOTAL	57	43	2	5	10	9	7	5

TABLE W (1), Continued

States	**A9:** Thermal Treatment with Off-Site Disposal	**A10:** Removal to Off-Site Locations After On-Site Treatment	**A11:** Air Stripping Technologies	**A12:** Leachate Treatment	**A13:** Pump and Treat, On-site Disposal	**A14:** Pump and Treatment, Off-site Discharge	Total
Alabama	0	0	0	0	0	0	2
Alaska	0	1	2	0	0	0	18
Arizona	0	1	0	0	1	3	7
Colorado	0	0	0	0	0	2	4
Florida	0	0	3	0	8	3	18
Illinois	0	0	2	3	6	4	25
Indiana	0	0	1	0	1	0	2
Kansas	0	0	20	1	11	31	81
Louisiana	0	1	0	0	0	1	4
Maine	0	0	2	0	0	3	10
Maryland	0	2	0	3	2	7	16
Massachusetts	0	0	0	0	21	0	24
Minnesota	4	0	5	19	2	20	83
Mississippi	0	0	1	0	0	7	13
Missouri	0	0	3	0	1	2	7
Montana	0	0	0	0	1	0	3
Nevada	0	0	1	0	8	1	11
New Jersey	1	1	3	1	10	6	37
New Mexico	0	0	0	0	1	0	1
New York	0	0	6	4	2	7	22
Ohio	0	0	2	1	1	1	6
Oklahoma	0	0	0	0	0	0	2
Pennsylvania	0	0	0	0	0	0	1
Rhode Island	0	0	4	0	0	0	5
South Carolina	0	0	1	0	2	0	4

Tennessee	0	0	3	0	1	0	7
Utah	0	0	1	0	0	1	2
Washington	0	1	4	1	0	5	15
TOTAL	5	7	64	33	79	104	430

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

(1) 31 states reporting.
(2) Number of Remedies by Type.

TABLE W(2)
Remedies by States (1)
2. Containment (2)

	ON-SITE								OFF-SITE		
States	**B1:** Surface Capping	**B2:** Surface Capping with Slurry wall	**B3:** Soil Cover	**B4:** Excavation and On-site Containment	**B5:** Encapsulation or Overpacking with Final On-Site	**B6:** Surface Drainage Control	**B7:** Solidification and Stabilization	**B8:** Slurry Wall	**C1:** Excavation and Final Removal to Off-Site Landfill	**C2:** Encapsulation or Overpacking with Final Off-Site Disposal	**C3:** Final Removal to Off-Site Landfill
Alabama	0	0	0	0	0	0	1	0	0	0	0
Alaska	0	0	0	5	1	1	0	0	1	1	2
Arizona	3	0	4	0	0	2	0	0	3	1	0
Colorado	0	1	0	0	0	1	0	0	2	0	0
Florida	0	0	0	0	0	0	0	0	13	1	2
Illinois	8	0	0	0	1	2	1	3	70	117	2
Indiana	0	0	0	0	0	1	2	0	2	7	5
Kansas	4	0	2	0	1	2	0	3	3	0	2
Louisiana	1	0	6	1	0	0	1	0	12	7	3
Maine	5	0	1	0	1	0	0	0	2	0	6
Maryland	21	1	24	2	0	10	4	0	26	4	40
Massachusetts	13	0	0	0	0	79	10	0	257	0	0
Minnesota	68	0	31	3	0	9	3	0	29	7	9
Mississippi	1	1	2	0	0	0	1	0	16	0	6
Missouri	4	0	2	1	0	0	0	0	14	13	2
Montana	1	0	3	3	0	4	1	0	12	2	0

Nevada	0	0	0	1	0	0	0	0	2	0	0
New Jersey	107	3	22	9	3	4	0	1	860	8	149
New Mexico	0	0	0	2	0	0	0	0	4	0	3
New York	14	2	1	1	0	1	0	1	50	12	49
Ohio	2	0	0	0	0	1	0	0	1	0	0
Oklahoma	0	0	0	0	0	0	2	0	6	25	0
Pennsylvania	0	0	0	3	0	0	0	0	0	0	0
Rhode Island	0	0	0	0	0	0	0	0	23	52	11
South Carolina	0	0	0	0	0	0	0	0	5	11	3
South Dakota	0	0	0	0	0	0	0	0	0	391	0
Tennesse	5	0	1	0	0	1	1	0	20	15	3
Texas	4	0	1	1	1	1	0	1	9	0	3
Utah	2	0	5	1	0	0	0	1	6	0	0
Washington	8	0	3	5	0	4	2	2	10	1	4
TOTAL	271	8	108	38	8	123	29	12	1458	675	304

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

(1) 31 states reporting.
(2) Number of remedies by type.

TABLE W(3)
Remedies by States (1)
3. Off-site Treatment and other Environmental Issues (2)

States	**D1:** Incineration and Disposal	**D2:** Pump and Treat at POTW with Discharge	**D3:** pH neutralization (Off-Site)	**D4:** Removal for Off-site Treatment	**D5:** Thermal Treatment with Disposal Discharge	**E1:** Alternate Water Supplied (Permanent or Temporary Water supply Reinstated)	**E2:** Population Relocated (Permanently or Temporary Relocation or Population Returned)	**F1:** Fence	**F2:** Guards	**F3:** Deed Restrictions	**G:** Innovative Technology
Alabama	11	0	1	25	0	0	0	1	0	0	0
Alaska	6	0	0	7	2	3	0	2	1	0	0
Arizona	0	0	1	0	0	0	0	4	1	1	0
California	0	0	0	0	0	0	0	0	0	28	0
Colorado	0	0	0	0	0	1	0	1	0	0	2

Florida	1	0	0	0	2	1	0	0	0	1	1
Illinois	5	1	0	1	0	4	0	1	1	1	1
Indiana	7	2	0	0	0	2	0	3	0	0	0
Kansas	0	0	0	0	0	4	0	1	0	0	3
Louisiana	2	0	0	1	0	0	0	2	0	1	0
Maine	3	1	0	7	0	7	0	4	0	0	0
Maryland	0	0	0	0	0	1	0	11	3	0	0
Massachusetts	1	1	0	1	0	1	0	2	0	0	1
Minnesota	8	5	1	8	5	16	1	10	0	0	1
Missouri	0	0	0	1	1	0	0	5	1	5	0
Montana	4	8	0	2	0	2	1	4	0	0	0
Nevada	1	0	0	3	0	0	0	0	0	0	0
New Jersey	4	3	0	32	3	2	0	18	2	15	1
New Mexico	2	0	0	0	0	1	0	1	0	0	0
New York	0	3	0	1	0	2	0	4	0	0	0
Ohio	0	0	0	4	0	0	0	1	0	0	0
Pennsylvania	0	0	0	20	0	2	0	2	0	0	0
South Carolina	4	0	3	6	1	0	0	10	1	0	1
Tennessee	0	0	0	1	0	0	0	2	0	0	0
Texas	0	0	0	0	0	2	0	40	0	0	0
Utah	1	0	0	0	0	0	0	1	0	1	0
Washington	3	0	1	9	0	14	0	2	0	2	0
TOTAL	63	24	7	129	14	65	2	132	10	55	11

Source: Kensington, System, Inc., "State and Territory System Documentation," August 1994.

(1) 31 states reporting
(2) Number of Remedies by type.

TABLE X
State Sites By Cost of Cleanup
1. Examples of Removals by Region, with Cost Less Than $60,000

Region	State	Site Name	Predominant Remedies	Total Cost	Duration In Months
Region I	Maine	Dauphin Disposal Facility	Alternate Water Supplied, Fence, Removal for Off-Site Treatment	$40,515	12
Region II	New York	West Almond Pesticide Storage Site	Final Removal to Off-Site Landfill	$36,850	57
Region III	Maryland	Evans Trail Dump Site	Excavation and Final Removal to Off-Site Landfill, Final Removal to Off-Site landfill, Fence, Guards	$35,007	1
Region IV	South Carolina	Spartan Leasing Co.	Encapsulation or Overpacking with Final Off-Site Disposal, pH neutralization, Removal for Off-Site Treatment	$34,830	17
Region V	Illinois	Route 122 Spill	Pump and Treat, On-Site Disposal, Excavation and Final Removal to Off-Site Landfill	$43,464	36
Region VI	New Mexico	Los Lunas Drug Labs	Incineration and Disposal, Excavation and Final Removal to Off-Site Landfill	$35,000	2
Region VII	Missouri	Robbins Property	Encapsulation or Overpacking with Final Off-Site Disposal	$26,000	35
Region VIII	Montana	Old Montana Prison Asbestos	Excavation and Final Removal to Off-Site Landfill	$59,000	*
Region IX	California	Sunrise River Industrial Park	Deed Restrictions	$35,070	*
Region X	Alaska	Aniak Sewer Spill	Removal to Off-Site Locations After On-Site Treatment, Removal for Off-Site Treatment, Guards	$48,890	6

* Data not available.

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

TABLE X
State Sites By Cost of Cleanup
2. Examples of Remedial Actions by Region, with Cost Less Than $60,000

Region	State	Site Name	Predominant Remedies	Total Costs	Duration in Months
Region I	Maine	Merril Transport Company Inc.	Biodegradation	$18,990	60
Region II	New York	Xerox Corporation Landfill	Surface Capping, Pump and Treat with Discharge Off-Site, Alternate Water Supplied	$17,332	67
Region V	Minnesota	Trio Solvent	Excavation and Final Removal to Off-Site Landfill	$40,000	22
Region VI	Louisiana	Acme Tube	Soil Cover, Excavation and Final Removal to Off-Site Landfill	$1,649	34
Region IX	California	Homart Development Corp/Lot 9	Deed Restrictions	$24,792	**

Region X	Washington	Elf Atochem - 2901 Taylor Way	Pump and Treat, Off-Site Discharge, Slurry Wall	$34,748	47

* Data available for sites in 6 regions only
** Data not available.

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

TABLE X
State Sites By Cost of Cleanup
3. Example of Removals by Region, with Cost $100,000 - $250,000

Region	State	Site Name	Predominant Remedies	Total Costs	Duration in Months
Region I	Maine	North Berwick Municipal Garage	Final Removal to Off-Site Landfill	$214,000	40
Region II	New York	Depew Manufacturing	Excavation and Final Removal to Off-Site Landfill	$199,852	2
Region III	Pennsylvania	Crown Industries	Removal for Off-site Treatment , Alternate Water Supplied	$200,000	12
Region IV	Tennessee	Kennon Site/Genesco	Excavation and Final Removal to Off-Site Landfill, Air Stripping	$199,555	27
Region V	Indiana	Julius Hancock Property	Excavation and Final Removal to Off-Site Landfill, Incineration and Disposal Off-Site	$245,000	21
Region VI	Texas	Hagerson Rd.	Excavation and Final Removal to Off-Site Landfill, Fence	$214,000	7
Region VIII	Montana	Apex Mill Bannack Statepark	Excavation and On-site Containment, Surface Drainage Control	$101,000	*
Region IX	Arizona	Chemonics	Surface Capping, Excavation and Final removal to Off-Site Landfill	$210,000	26
Region X	Alaska	Sterling Chevron	Soil Aeration	$166,020	19

* Data not available.

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

TABLE X
State Sites By Cost of Cleanup
4. Example of Remedial Actions by Region, with Cost $100,000 - 400,000

Region	State	Site Name	Predominant Remedies	Total Cost	Duration in Months
Region I	Maine	Blackstrap Road Site	Alternate Water Supplied	$338,274	1103
Region V	Illinois	Refinery Products	Excavation and Final Removal to Off-Site Landfill	$195,453	96
Region VII	Kansas	Crankshaft Die	**	$112,000	**
Region X	Alaska	Cooks Corner Tesoro	Soil Aeration Technologies	$294,740	5

* Data available for sites in 4 regions only.
** Data not available.

Source: Kensington, System, Inc., "State and Territory System Documentation," August 1994.

TABLE X
State Sites By Cost of Cleanup
5. Examples of Removal and Remedial Actions by Region, with Cost Over a Million Dollars

State	Site Name	City	Removal or Remedial	Code	Predominant Remedies	Total Dollar	Start Date	Completion Date	Duration in Months
REGION 1									
Massachusetts	Mendon Road Site	Attleboro	removal	B	C1	2,315,307	1/15/87	7/15/87	6
REGION II									
New York	Bedford Village Wells Shopping Arcade	-	removal	B/C	-	2,124,988	-	-	-
	Bossert Manufacturing Corp.	-	removal	B/C	-	6,750,000	-	-	-
	Dewy Loeffel	-	remedial	E	B2,C3,F1	1,887,610	11/1/80	8/1/84	48
	Diarsenol Co. Kingsley Park	-	removal	B/C	-	1,998,375	-	-	-
	Edgemore Landfill	-	removal	B/C		4,727,542		-	-
	Gorick Dump	-	remedial	E	A11	1,515,098	10/1/89	3/1/92	29
	Lehigh Valley Railroad Derailment	-	removal	B/C	-	1,903,256	-	-	-
	Madison Wire Company (Orban Industries)	-	removal	B/C	-	5,126,737	-	-	-
	Mahopac Business District Wells	-	removal	B/C	-	1,555,447	-	-	-
	Mead Property	-	removal	B/C	-	1,273,937	-	-	-
	Nanpanoch Paper Mill	-	removal	B/C	-	18,150,058	-	-	-
	Novack Farm	-	removal	B/C	-	3,424,577	-	-	-
	Pfohl Brothers Landfill	-	removal	B/C	-	7,047,627	-	-	-
	Route 146A Barrel Site	-	removal & remedial	B & E	C1,C3	1,071,026	2/1/90	3/1/92	25
	Sweden 3; Chapman	-	removal	B/C	-	4,315,237	-	-	-
	Union Road Site	-	removal	B/C	-	1,571,342	-	-	-
	Van Der Horst Corporation	-	removal	B/C	-	1,142,103	-	-	-
	Van Der Horst Plant #2	-	removal	B/C	-	1,273,300	-	-	-
	Wallkill Town Landfill	-	removal	B/C	-	1,206,633	-	-	-

	Whitestone Municipal Landfill	-	removal	B/C	-	7,304,770	-	-	-
REGION III									
Pennsylvania	Giordano Waste	Butter Township	removal	B	D4	2,000,000	4/1/89	4/1/90	7
REGION IV									
Florida	Belleview/Union 76	Belleview	removal & remedial	B & E	A11,A1,A13,D1,G	1,737,888	8/7/84	7/10/91	83
	K & K Grocery	New Hope	remedial	E	A11,A13,A5,D5	1,334,424	9/1/86	12/4/91	63
	Vroom	Loughman	removal & remedial	B & E	A13,C1	2,728,613	6/88/84	10/12/90	76
	Wacissa	Wacissa	removal & remedial	B & E	A13,D5,E1	1,539,046	6/20/85	9/29/91	75
REGION V									
Michigan	Cass St Area Edwardsburg	Edwardsburg	removal	B	-	1,273,400	-	-	-
	Chief Noonday Archwood	Yankee Springs Twp	removal	B	-	1,117,100	-	-	-
	Forest Lane GW Contamination	Traverse City	removal	B	-	1,338,400	-	-	-
	Former 753 Station Area	Saul Ste Maure	removal	B	-	1,215,000	-	-	-
	Hamburg Unadilla Rds Contam Area	Pinkney	removal	B	-	2,985,350	-	-	-
	Res Well Sable Road	Union City	removal	B	-	1,598,500	-	-	-
	Res Wells Eben Junction	-	removal	B	-	2,011,000	-	-	-
	Res Wells Rock	-	removal	B	-	2,690,000	-	-	-
	Res Wells Sand Lake	San Lake VLG	removal	B	-	2,023,988	-	-	-
	Res Wells Sashabaw Rd Area	Drayton Plains	removal	B	-	1,052,961	-	-	-
	Res Wells Tekonsha	Tekonsha	removal	B	-	4,037,537	-	-	-
	Res Wells Trenary	-	removal	B	-	1,653,315	-	-	-
	Section 25 Gun Plain Township	Plainwell	removal	B	-	1,460,900	-	-	-
	South Ninthst Vlg of Wells	-	removal	B	-	1,460,000	-	-	-
	Staebler Road GW Contam	Ann Arbor	removal	B	-	2,023,100	-	-	-

	US Aviex Huntley Rd	Niles	removal	B	-	1,044,000	-	-	-
Illinois	Ability Drum	Washington	removal	B	C2	2,129,788	11/30/84	-	0
	Lauder PCB Site	Beardstown	removal	B	C1,D1,A5	3,626,994	11/30/84	-	24
	Steagal Landfill	Galesburg	removal	B/C	F1,F2,A12,A13,B1	3,769,631	11/30/84	12/30/91	66
REGION IX									
California	139 Th Street San Leandro	San Leandro	removal	B/C	-	1,552,435	-	9/30/92	0
	ASARCO	Selby	removal	B/C	-	1,428,233	-	12/21/92	0
	Bay Area Drum Company	San Francisco	removal	B/C	-	4,299,099	-	7/30/90	0
	Brown & Bryant Shafter Facility	Shafter	removal	B/C	-	1,170,241	-	11/30/92	0
	Chatham Brothers Barrel Yard	Escondido	removal	B/C	-	8,684,139	-	6/30/90	0
	Chico Groundwater Central Plume	Chico	removal	B/C	-	3,658,842	-	7/1/90	0
	Chico Groundwater Southwest Plume	Chico	removal	B/C	-	3,658,842	-	1/30/92	0
	Chromalloy General Radiator	Sacramento	removal	B/C	-	1,221,077	-	12/30/87	0
	Cook Battery Coakley Battery	Oakley	removal	B/C	-	1,360,446	-	6/29/92	0
	Folsom Prison	Represa	removal	B/C	-	1,137,129	-	9/30/88	0
	Gatx Annex Terminal San Pedro	San Pedro	removal	B/C	-	1,169,871	-	11/9/92	0
	Hillview - Eleanor Arca Plume	Los Altos	removal	B	-	1,576,754	-	11/6/92	0
	Jensen Lumber Company	Hyampon	removal	B	-	1,670,915	-	6/30/89	0
	L & M Planting	Oakland	removal	B	-	1,062,903	-	3/31/89	0
	Lubrication Company of America	Canyon Country	removal	B/C	-	4,132,270	-	6/30/92	0
	North San Bernardino Area	San Bernardino	removal	B/C	-	4,316,685	-	8/30/90	0
	Rio Bravo Disposal Facility	Shafter	removal	B/C	-	1,297,507	-	6/30/92	0
	Southland Oil	Commerce	removal	B/C	-	1,311,656	-	10/29/92	0
	SP, SAC - Ponds and Ditch	Sacramento	removal	B/C	-	1,629,295	-	6/15/92	0
	Summer del Caribe, Inc.	Richmond	removal	B/C	-	1,629,295	-	6/15/92	0

	Valley Planting Company	Central Valley	removal	B	-	1,851,924	-	6/30/90	0
	Verticare Helicopters	Salinas	removal	B	-	1,469,591	-	12/15/92	0

Source: Kensington, System, Inc., "State and Territory System Documentation," August 1994.

Code B - Completed Removal
Code C - Active Remedial
Code E - Completed Remedial Action

TABLE Y
Remedial Action Jobs by Craft for All UMTRA Sites

Craft	Percent Gross Pay Earned	Average Hourly Wage	Number of Remedial Action Jobs
Driver	28%	$16.12	2,935
Electrician	1%	$20.78	81
Laborer	17%	$13.01	2,208
Mechanic	6%	$16.96	598
Operator	38%	$15.18	4,230
Other Crafts	10%	$14.94	1,131
TOTAL	100%	-	**11,183**

Source: Ruth Ruttenberg & Associates, Inc. Data Base.

TABLE Z
Remediation Costs by State (in Descending Order by Cost)

States	# Sites	Total Cost	Average State Cost
Colorado	1	3,200,000	3,200,000
Virginia	2	2,500,000	1,250,000
New York	210	211,266,459	1,006,031
New Jersey	1,115	343,694,743	974,329
Kansas	16	33,053,000	835,000
Texas	16	17,464,000	701,076
Florida	25	12,184,849	487,394
California	223	90,792,505	407,141

Michigan	496	159,226,582	321,021
Pennsylvania	27	8,120,000	304,615
Montana	4	1,010,000	253,333
Arizona	61	32,139,733	231,929
South Carolina	35	7,036,201	201,034
Indiana	11	1,682,128	168,113
Illinois	513	126,459,118	167,227
Minnesota	178	92,525,000	127,562
Alaska	41	3,645,801	95,161
Maine	31	3,337,516	89,742
Washington	131	10,944,364	83,545
Maryland	14	2,036,816	77,469
Massachusetts	33	2,553,857	77,390
Delaware	18	1,255,500	69,750
New Mexico	3	5,135,000	67,500
Tennessee	72	6,719,579	51,175
Missouri	8	11,218,000	42,667
Louisiana	24	985,483	41,062
Utah	6	14,130,389	32,597
Alabama	26	190,000	7,308
Wisconsin	183	939,021	5,131
Oklahoma	29	85,590	2,951
TOTAL:	3,552	1,205,531,234	-

Source: Kensington System, Inc., "State and Territory System Documentation," August 1994.

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APPENDIX IV

Tables not in text, but available on request

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PEAK TIME TABLES

TABLES BY SITE

SACRAMENTO ARMY DEPOT

DURANGO

GRAND JUNCTION UMTRA SITE

RIFLE UMTRA SITE

HOLLINGSWORTH SOLDERLESS TERMINAL COMPANY

CHEROKEE COUNTY

PADUCAH GASEOUS DIFFUSION PLANT

BONFOUCA

BOG CREEK FARM

BRIDGEPORT RENTAL & OIL, SERVICES

LIPARI LANDFILL

LONE PINE LANDFILL

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APPENDIX VI

Acronym List

AFB	Air Force Base
ATSDR	Agency for Toxic Substances and Disease Registry
CAMUs	Corrective Action Management Units
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DOD	Department of Defense
DOE	Department of Energy
DEPE	Department of Environmental Protection and Energy (New Jersey)
DERP	Defense Environmental Restoration Program
EPA	United States Environmental Protection Agency
FR	Federal Register
FS	Feasibility Study
FY	Fiscal Year
HAZWOPER	Hazardous Waste Operations and Emergency Response
HRS	Hazardous Ranking System
HSWA	Hazardous and Solid Waste Amendments
IRP	Installation Restoration Program (DOD)
NCP	National Contingency Plan
NPL	Superfund National Priorities List of Hazardous Waste Sites (EPA)
OHW	Other Hazardous Waste Operations (DOD)
OMB	Office of Management and Budget
OPM	Office of Personnel Management
OSWER	EPA's Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyl
PRP	Potentially Responsible Party
RA	Remedial Action
RAC	Response Action Contract Strategy
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
ROD	Record of Decision
SARA	Superfund Amendment and Reauthorization Act

SI	Site Investigation
SITE	Superfund Innovative Technology Evaluation
SWDA	Solid Waste Disposal Act
SWMU	Solid Waste Management Unit
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TERC	Total Environmental Restoration Contracting
TSCA	Toxic Substance Control Act
TSD	Treatment, Storage or Disposal
TSDF	Treatment, Storage or Disposal Facility
TSF	Treatment and Storage Facility
VOC	Volatile Organic Compound
UST	Underground Storage Tank

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APPENDIX VII

Glossary

AerationAir Sparging	A method used to remove VOCs from groundwater. Compressed air is forced through a well screen in the aquifer forcing contaminants into the soils above the groundwater where they may removed by soil vapor extraction.
Air Stripping	The change of dissolved molecules from a liquid waste stream to a flowing gas. It is normally carried out as a continuous operation that employs a packaged tower. For air stripping, liquid waste is pumped near the top of stripping column and flows downward through the tower, concurrent to an upward air flow. As the air flow contacts the liquid wastes, the volatile organics are stripped from the liquid waste.
Aquifer	A layer of water mixed with permeable rock, sand, or gravel.
Backhoe	An excavating machine with a hoe-type or pull-type shovel. May be rubber-tired or tracked.
Biological Treatment	Biological treatment is the microbial transformation of organic compounds. Biological treatment processes can alter inorganic compounds such as as ammonia and nitrate, and can change the oxidation state of certain metal compounds. Includes in-sity 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.
Bioremediation	An innovative technology in which bacteria are used to break down petroleum products in soil. It currently addresses only a few biodegradable compounds, but is still being developed.
Biosparging	An in situ technique which delivers oxygen to the saturated and unsaturated zones to stimulate the aerobic biodegradation of organic contaminants in the groundwater. Oxygen is delivered at a slow rate so biodegradation rather than volatilization is encouraged.

Bioventing	An innovative technology used to degrade VOCs.
Bulldozer	Crawler tractor with a hydraulic or cable-controlled front-mounted blade.
Capping	The process of covering buried waste materials with a cover material (usually clay). Capping includes the construction of multilayered caps and bottom liners designed to contain solid waste in place, to prevent the migration of precipitation, or entry of vegetation or animals into the waste cell, and to collect and distribute any leachate generated by the waste. Includes procurement of materials, loading, hauling, spreading, compaction of cap layers, establishment and maintenance of turf, and containment systems (liners) beneath waste piles or landfills. Cap layers and bottom liners include impervious clay layers, bentonite layer, granular drainage layers, geotextile membrane, flexible membrane liners, random barrier, revegetation, erosion control, drainage and leachate collection system, manholes, sumps, lift stations, paving cover, blast protective cover and testing.
Carbon Adsorption-Liquids	Carbon adsorption use activated carbon to remove organic contaminants from liquid waste streams. Granular activated carbon is applied in stationary column or filter bed, where organic contaminants are adsorbed. Costs associates with carbon adsorption are isotherm tests, granular activated carbon columns, prefilters, and costs associated with regenerating the spent carbon.
Chemical Treatment	The process in which hazardous wastes are chemically changed to remove toxic contaminants from the environment. Type of treatment included in this account are oxidation, hydrolysis, photolysis, dechlorination, and electrolysis reactions. Includes process equipment and chemicals required for treatment.
Construction Completion	The point in the cleanup process at which physical construction is complete for all remedial and removal work required at the entire site. Construction is officially complete when a document has been signed by EPA stating that all necessary remediation has been finished. While no further construction is anticipated at the site, there may still be a need for long-term, on-site activity before specified clean-up levels are met (e.g., restoration of groundwater and surface water). Although physical construction may not be necessary at some sites, these sites are also included in this category to fully portray EPA=s progress.
Dechlorination	A type of chemical treatment which results in the removal or replacement of atoms bonded to hazardous compounds.
Decontamination	The process of removing or neutralizing hazardous substances on personnel and equipment.
Decontamination & Decommissioning (D&D)	Activities associated with shutdown and final cleanup of a nuclear of 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.
Ex Situ Bioremediation: Biomounding	Removes biodegradable contaminants from excavated mounds of soil. Nutrients are added tot he soil mounds to facilitate bioremediation. Aeration conduits and irrigation systems are constructed in the mound.
Ex Situ Bioremediation: Land Farming	Removes biodegradable contaminants from excavated soil by spreading the excavated soil and added nutrients over a lined treatment area which is periodically cultivated to expedite the natural release of VOCs and breakdown of the contaminants.
Facility Shutdown Activities	Any activities that are necessary for the closing of a nuclear or other facility. These include sampling, defueling, plant decontamination, inspections, and buildings

	entombment.
Feasibility Study	Performed at the same time as the remedial investigation, this is the stage where EPA/contractors decide if the remedial designs which they are thinking of doing, are feasible for that particular site.
Fiscal Year	Government fiscal year, from October 1 through September 30.
Fuming Gasification	A thermal treatment process which removes contaminants from solids and soils as metal fumes and organic vapors. Organic fumes can then be burned as fuel, and metal fumes can be recovered and recycled.
Groundwater	Water within the earth that supplies wells and springs.
Hazardous Materials Emergency Response	Response to any substance or material in any form or quality which poses an unreasonable risk to safety and health and property, or poses a threat to waterways and the environment when released.
Hazardous Ranking System	Used by EPA as criteria to determine if a site should be placed on the National Priorities List. A numerically based system, it evaluates the relative risks posed by a site to both human health and the environment.
Hazardous Substance Emergency	Uncontrolled or illegal releases or threatened releases of chemicals or their hazardous byproducts.
Incineration	The process of burning soils or sludges to destroy contaminants.
Innovative Technology	Treatment methods used which, to date, have not been proven by performance and cost data.
In Situ	Within place, refers to the location of activities.
In Situ Air Sparging with Soil Vapor Extraction	Removes dissolved volatile contaminants from groundwater by injecting air into the saturated area. Air forms bubbles that rise into the unsaturated area, carrying trapped and dissolved contaminants. Extraction wells in the unsaturated area capture trapped air, which can be treated through a variety of vapor treatment options.
In Situ Bioremediation	Removes biodegradable contaminants from groundwater by using microorganisms and supplemental oxygen and nutrients to break down petroleum products in the groundwater.
In Situ Bioremediation: Bioventing	Removes biodegradable contaminants from unsaturated soils by injecting oxygen into the soil, which stimulates the aerobic biodegradation of the organic contaminants in the soil. Oxygen is delivered at a low rate which encourages biodegradation rather than volatilization.
In Situ Passive Biodegradation (Natural Attenuation)	Removes biodegradable contaminants from soil by using microorganisms to break down petroleum products in the soil.
In Situ Radio Frequency (RF) Heating Process	The in situ radio frequency heating process utilizes electromagnetic energy in the radio frequency band to heat soil rapidly. The process can be used to heat the soil to a temperature range of 150-250EC. The contaminants are vaporized and/or boiled out along with water vapor formed by the boiling of native soil moisture. The gases and vapors formed upon heating the soil are recovered and treated on site.
In Situ Soil Vapor Extraction	Removes contaminants from unsaturated soils by using a vacuum pump to bring fresh air into the ground, pushing the contaminants to the surface where they may be treated.
In Situ Vitrification	The in-place encapsulation of contaminated soils and sludges into a solid glassy matrix by melting the soil using large amounts of electrical current. Assemblies

	include electrical power distribution, electrodes, graphite placed over the soil to establish a conductive path and exhaust hood system to capture gaseous wastes.
Land Farming	Removes petroleum compounds from soils. Contaminated soils are removed from the ground, spread over a given area, and periodically cultivated to speed up the release of VOCs and breakdown of the contaminants.
On-Site Low Temperature Thermal Desorption	Removes contaminants from volumes of soil over 1,000 cubic yards by heating contaminated soils at less than 1,000 degrees Fahrenheit which causes contaminants to vaporize. The vaporized contaminants are then treated by air emissions treatment systems.
Operable Unit	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 release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site.
Operation & Maintenance	This phase, if necessary, follows the Remedial Action. It may include actions such as monitoring groundwater or periodic site inspections to ensure that the remedial actions are effective.
Physical Treatment	Hazardous constituents in wastes are not destroyed, but instead are separated and two waste streams are produced. One is a concentrated volume of hazardous material and a second is a nonhazardous soil or liquid.
Pollution Prevention	Pollution prevention means reducing the volume and/or toxicity of pollution at the source of its generation.
Preliminary Assessment	The phase in which EPA determines whether the site poses potential threats to human health or the environment.
Presumptive Remedy	Preferred technologies for common categories of sites for common categories of sites, based on historical patterns of remedy selection and EPA=s scientific and engineering evaluation of performance data on technology implementation.
Pump & Treat	Through the use of extraction wells, brings contaminated groundwater above the ground. Water is then treated through granulated activated carbon, air stripping, or bioremediation.
Record of Decision	A document which A document which shows the results of the RI/FS. It then specifies the chosen as well as the alternative remedies for the site.
Remedial Action	The phase in which the waste is actually treated, removed or contained.
Remedial Design	The phase in which engineers come up with detailed specifications for the selected remedy.
Remedial Investigation	The phase in which EPA/contractors determine the extent of contamination to a site is assessed, treatment alternatives are evaluated.
Removal Action	Short-term actions which stabilize or cleanup a hazardous site that poses a threat to human health or the environment. Typical removal actions include removing tanks or drums of hazardous substances on the surface, installing fencing or other security measures, and providing a temporary alternate source of drinking water.

Resource Conservation and Recovery Act	Regulatory system which tracks hazardous wastes from the time they are generated until final disposal. Requires safe hazardous waste management and dictates standards for treating, transporting, strong, and disposing of hazardous waste. Designed to prevent the creation of new hazardous waste sites.
Site Restoration	Includes, topsoil, seeding, landscaping, restoration of roads and parking, and other hardscaing 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.
Slurry Wall	Narrow vertical trenches, typically 24-36 inches wide, excavated through previous materials to a relatively impervious underlaying strata and backfilled with a soil/bentonite or cement/bentonite slurry mixture. This provides a vertical barrier to reduce the horizontal permeability of soil. Slurry wall displacement. The operation of batch plant equipment such as storage tanks, ponds, grout plants, circulation pumps and batchmers are also included.
Soil Aeration	Process by which contaminated soil is exposed to air through tilling or with a submerged pump. The air reacts with the waste to detoxify or decontaminate it.
Soil Flushing	An in-situ treatment of soils, sludges and sediments with water (with or without additives) to remove hazardous, toxic or radioactive contaminants. The wastewater is the recovered and treated. Assemblies include infiltration basins, water storage tanks with associated pumps, valves, and piping, groundwater recovery wells, and treatment for the recovered water.
Soil Vapor Extraction (SVE)	Uses a vacuum pump to draw fresh air into the ground causing toxic substances to rise to the surface where they may be treated. Most frequently used technology for chlorinated and nonchlorinated VOCs in soil.
Soil Venting	Technology used to remove gasoline vapors from soil without excavation. This method may be applied either passively (with vents that are open to the atmosphere) or actively (using pressure or vacuum pumps).
Soil Washing	Mechanical action and water which sometimes has additives physically removes contaminants from soil particles. In addition, agitation of the soil particles allows the smaller diameter, more highly contaminated fines to separate from the larger particles, thereby reducing the volume of material requiring further treatment.
Solid Waste Management Unit	Any unit where solid wastes have been placed at any time, irregardless of whether the unit was intended for the management of solid waste.
Solidification	Stabilizes and prepares non-solid radioactive waste for disposal through methods such as calcining (burning).
Solvent Extraction	Using the correct solvent for the particular waste to be treated, organic contaminants are solubilized singularly and removed from the waste.
Stabilization/Solidification Fixation	Wastes are mixed with a hardening or binding agent, called a fixative, to reduce the mobility of the wastes or to solidify them.
Tank	A stationary device, designed to contain an accumulation of hazardous waste, which is constructed primarily of non-earthen materials (e.g., wood, concrete, steel, plastic) which provide structural support.
Thermal Desorption	An innovative technology that treats a vast array of VOCs and SVOCs. A way to separate or concentrate organic waste for further treatment.
Uranium Mill Tailings	Naturally occurring radioactive rock and soil that result from uranium mining.

Vacuum Enhanced Pump & Treat	A process than increases the rate of pumping (reducing remediation time) by using a surface-mounted vacuum pump to remove contaminated soil vapors.
Vapor Extraction	A remediation technology which removes volatile organic compounds from soil by pulling air through the soil and venting it through an off-gas treatment system, condensate handling system, instrumentation and controls. Vapor extraction assemblies include drilling withdrawal and air injection wells, packing, capping, gravel and bentonite, positive displacement air blowers, manifold piping, vapor phase carbon adsorption units and well screens.
Vitrification	Mixing high-level liquid waste with molten glass in order to convert it into a stable solid form.
Volatile Organic Compound (VOC)	Carbon-containing compounds that readily change from liquid to gas as normal temperatures and pressures.

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