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Emergency Response and Removal

Robin Jenkins, Heather Klemick, Elizabeth Kopits, and Alex Marten

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Abstract

Over the past five decades, the federal government has enacted laws and developed regulations to manage actual and threatened hazardous releases. This paper describes a relatively understudied component of the nation's response capability – the Superfund Emergency Response and Removal (ERR) Program. Drawing on a new dataset of 113 recent removal actions on 88 sites in the Mid-Atlantic region, we find a great deal of diversity across sites, from the discovery and cause of contamination to the types of risks and the cleanup strategy. The program addresses traditionally studied media such as soil, water, and air contamination, as well as risks from not-yet-released contained contaminants and potential fire or explosion. One of the program's major strengths is its ability to address this wide range of threats, even though this very heterogeneity complicates research efforts to assess its net benefits. We describe the involvement of

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potentially responsible parties and EPA expenditures on removal actions. Finally, we consider future challenges for research into the net benefits of the program.

1 Introduction

Oil, chemicals, and other hazardous substances are ubiquitous throughout the U.S. economy. Each year, large quantities of these substances are mined, manufactured, handled, transported, discarded, and in the process, sometimes accidentally released. Currently between 20,000 and 30,000 incidents are reported in the U.S. annually involving the release or potential release of oil or hazardous substances (U.S. EPA 2010a, U.S. National Response Team 2009). Over the past five decades or so, the federal government has enacted laws and developed regulations to manage actual and threatened hazardous releases with increasing concern about possible deliberate releases caused by terrorists. This paper describes a key component of the nation's response capability – the Superfund Emergency Response and Removal (ERR) Program.

Congress established the ERR Program in 1980 with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). CERCLA initially established two land cleanup programs: the well-publicized Superfund Remedial Program, which created the National Priorities List (NPL), and the lesser known Superfund ERR Program. The ERR Program was set up to quickly address imminent threats to public health or the environment, while the Remedial Program's NPL targets sites that require long-term remedial action (U.S. EPA 2010c).

Because of the large number of emergency contamination events, the ERR Program has responded to contaminants at more than three times the number of sites that appear on the NPL (U.S. EPA 2010e). Yet, in the economics literature there is a virtual absence of research about it compared to the scores of papers focused on the NPL. One reason for this imbalance might be the lack of readily available data characterizing the ERR Program. This absence of information limits both opportunities for analysis and general understanding about the program. The current paper addresses this gap first by describing the evolution of the ERR Program and second by presenting detailed information about 113 recent removal actions in the Mid-Atlantic states, known as EPA Region 3. The goal of the Program is to address imminent threats, but what kinds of threats, and who was threatened? What environmental media were affected, and how much did EPA spend removing the risk? This paper addresses these and other questions in an effort to better understand the impacts of the ERR Program.

The removal sites in our new dataset were usually located in population centers with a variety of at-risk sub-populations, including residents, employees, recreational users, and often children. Sites were diverse along many dimensions, from the discovery of contamination to the cleanup strategy. Contamination most frequently resulted from improper disposal, handling, or storage of materials. Not only were soil, air, groundwater, and surface water contamination prevalent, but risks from not-yet-released contained contaminants and potential fire or explosion were also common. One of the ERR Program’s major strengths is its ability to address a wide range of threats to public health and the environment, even though this very heterogeneity complicates research efforts to assess the program.

The paper begins with a description of the evolution of the ERR Program within the context of emergency management in the U.S. and presents statistics on the program nationwide. Section 3 describes our Region 3 dataset and data gathering process. Section

4 provides a thorough characterization of the removal actions, including the causes of contamination and EPA involvement, the types of contamination and risks found, and the nature of cleanup activities. The paper concludes with ideas for research and a brief discussion of issues surrounding estimation of social benefits of removal actions.

2 Evolution of the ERR Program

EPA's ERR Program is part of an evolving set of federal rules addressing emergency management. Response programs have targeted an increasing set of environments, starting with the sea and expanding inland, and an increasing variety of contaminants, starting with oil and expanding to all hazardous substances. The circumstances requiring emergency response have grown from vehicle or equipment accidents to radiological incidents, natural disasters, and terrorist attacks. This section describes the history of the ERR Program in light of the country's ever-changing needs and circumstances. It highlights the Program's intimate connections to the National Contingency Plan, the Oil Spill Program, and the Superfund Remedial Program (the NPL). It ends by reporting statistics and geographic information to characterize the program's activities to date.

2.1 The National Contingency Plan and EPA's ERR Program

Although it was the first national program to address contamination of land posing an imminent threat, the ERR Program built on existing federal authorities to address hazardous releases at sea. In 1968 President Johnson approved the first National Oil and Hazardous Substances Pollution Contingency Plan, commonly known as the National Contingency Plan (NCP). It was a reaction to the first major and highly publicized oil spill at sea. In March, 1967, the supertanker Torrey Canyon snagged on rocks off the coast of England, releasing more than 35 million gallons of oil and contaminating approximately 120 miles of Cornish and French coastlines. Allegedly, the British government handled the incident poorly, with no clear lines of authority or plan of attack (British Broadcasting Corporation 2010, British Broadcasting Corporation Cornwall 2010, U.S. EPA 2010b, U.S. National Response Team 2009). The NCP was an effort to be better prepared for similar future incidents in the U.S.

The original NCP targeted oil spills into navigable U.S. waters and provided an organized approach for addressing a hazardous substance release incident, including reporting, containment, and cleanup. It also created a National Response System identifying a hierarchy of responders and emergency contingency plans and addressing the roles of federal, state, and local officials. It established the precursors to the present day National Response Team to develop national level emergency preparedness for oil and later hazardous substance releases. The NCP required the pre-designation of On Scene Coordinators (OSCs) who would direct response efforts. In general the U.S. Coast Guard provides OSCs for the coastal zone and the EPA for the inland zone (U.S. EPA 2010b, U.S. National Response Team 2009).

Over the years, and through various authorities, Congress has expanded the NCP to more thoroughly address potential public health threats. The 1972 Clean Water Act mandated that the NCP address all hazardous releases into navigable waters. Later, CERCLA expanded the scope to address hazardous releases into any environmental media, in part through establishing the ERR Program. CERCLA also established a trust fund to pay for cleaning up sites when the responsible parties were unable or unwilling to finance the cleanup. The Oil Pollution Act of 1990 again broadened the NCP authority and, among other changes, established the Oil Spill Liability Trust Fund, which allows for compensatory payments for damages from oil spills (U.S. EPA 2010c, 2010d; U.S. National Response Team 2009, 2010).[2]

During this continued expansion of the NCP the ERR Program has taken on a first-responder and oversight role while also addressing an expanding set of threats. The Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 authorized the federal government to address releases of hazardous substances due to natural disasters in part through the ERR Program (Probst and Konisky 2001). Three 2003 Homeland Security Presidential Directives directed EPA to respond to terrorist incidents involving hazardous materials (U.S. EPA 2010a,c). In 2004, EPA established an Office of Emergency Management that consolidated the Chemical Emergency Preparedness Office, Oil Spill Prevention Program, and Superfund Emergency Response and Removal Program to ensure improved coordination in both preparing for and responding to emergencies involving oil or hazardous substances (U.S. EPA 2005a). Currently the National Response Team is chaired by EPA, vice-chaired by the U.S. Coast Guard, and includes thirteen additional participating agencies (U.S. National Response Team 2009).

2.2 Removal and Remedial Actions: Complementary Responses

The ERR and Remedial Programs share many key features, such as liability rules for responsible parties, access to the CERCLA trust fund, site management led by an individual coordinator or manager, and so on. Congress set up the two programs to

[2] Sites contaminated by crude oil or refined petroleum are not covered by CERCLA, but sites with waste oil that includes contaminants not normally found in crude oil or refined petroleum, or contaminants in quantities exceeding what would naturally be found in crude oil or petroleum, are (U.S. EPA 1987).

address a continuum of response needs – from emergencies to large contaminated sites dominated by longer term risk. The continuum is refined further within the ERR Program, where there are three formal categories of removal actions based on the urgency of site conditions. Emergency actions require response within hours to days; time-critical actions require response within weeks to months; and non-time-critical removal actions typically allow for a planning period of six months before action is deemed necessary. Engineering evaluation and cost analysis are required prior to initiation of non-time critical actions and more community involvement is sought (U.S. EPA 2000a).

On Scene Coordinators (OSCs) are responsible for evaluating reported releases to determine the potential for a removal action. They begin by assessing the size and nature of the release. One job of the OSC is to determine the ability of the potentially responsible parties (PRPs) or local authorities to address the release. Cleanups can be PRP-led when PRPs are identifiable, solvent, and capable; however if federal assistance is necessary the cleanup may be led by EPA (U.S. EPA 2010c). In cases where the cleanup is EPA-led it may still be funded by PRPs, or the government retains a right to seek future cost recovery.

Initially, EPA-financed removal actions were limited to less than six months of time and $1 million in expenditures. The limits were relaxed by the Superfund Amendments and Reauthorization Act of 1986, which doubled them to one year and $2 million, though the statute allows waivers following appropriate review and consideration; for example for continuing emergency conditions. (U.S. GAO 1996a,b; Probst and Konisky 2001). EPA requires Headquarters concurrence before the ERR

Program can spend more than $6 million for a removal action (U.S. EPA 2000a). As we discuss later, our own data reflect the flexibility in these limits.

Naturally, the lengthiest non-time critical actions begin to resemble sites handled by the Remedial Program. In fact, after ten years of managing NPL cleanups and given public pressure to do more in a shorter period of time, EPA turned to the ERR Program to pick up the pace at NPL sites. In 1992 a new Superfund Accelerated Cleanup Model allowed OSCs to hasten cleanups at Remedial sites by relying more heavily on removal authority in cases presenting imminent and substantial danger to public health or welfare (U.S. EPA 2000a). A study by the Government Accountability Office (1996a,b) found that non-time critical removals can be appropriate for addressing the high-risk portions of NPL sites and can achieve comparable risk reductions with less time and expense due to streamlined planning, though remedial actions remain essential for conducting the more complex cleanup operations at these sites.

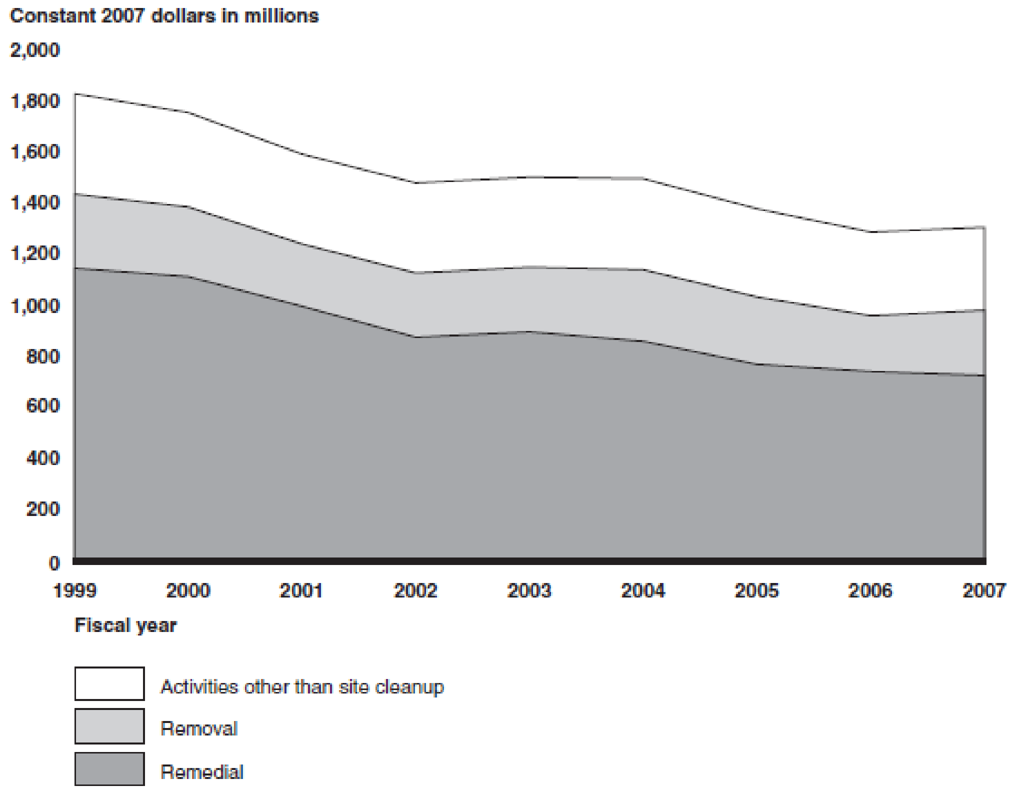
In addition to removal actions occurring at NPL sites to address imminent threats, removal sites can also subsequently be listed on the NPL when remaining contamination requires further remediation. Approximately 60 percent of all 1,674 NPL sites have had at least one removal action; at nearly half of those sites the action was started prior to the site's final listing on the NPL. Because the ERR Program addresses a much larger universe than NPL sites, only about 20 percent of all removal actions have occurred at NPL sites (U.S. EPA 2010e).

Within the past 20 years the nominal budget for the Superfund program to address both removal and remedial activities has remained fairly constant, resulting in a significant decline in real dollars.[3] As shown in Figure 1, expenditures on the ERR Program averaged about one-third of expenditures on the Remedial Program during the 2000s.[4] These expenditures do not include additional funding for homeland security in recent years, such as a supplemental Congressional appropriation in 2002 that helped pay for emergency response activities at the Capitol Hill anthrax site (U.S. GAO 2003). Funding for EPA's Homeland Security Preparedness, Response, and Recovery Program, which builds on the ERR Program to support EPA's capacity to respond to catastrophic incidents through activities such as OSC training and laboratory work, has averaged about $45 million since 2002, suggesting that some additional resources have helped support the expanded role of the program in responding to homeland security incidents.

Figure 1: EPA Superfund Expenditures, Fiscal Years 1999 through 2007

[3] The Superfund tax expired at the end of 1995. Since then, Superfund program funding has been financed primarily from General Revenue transfers to the Superfund Trust Fund. Reinstatement of the Superfund tax has been considered and rejected several times and is currently under consideration (U.S. EPA 2010f).

[4] Budget data collected from EPA FY2000-FY2011 Annual Performance Plan and Congressional Justification documents, available at http://www.epa.gov/budget/ (accessed Aug. 2010).



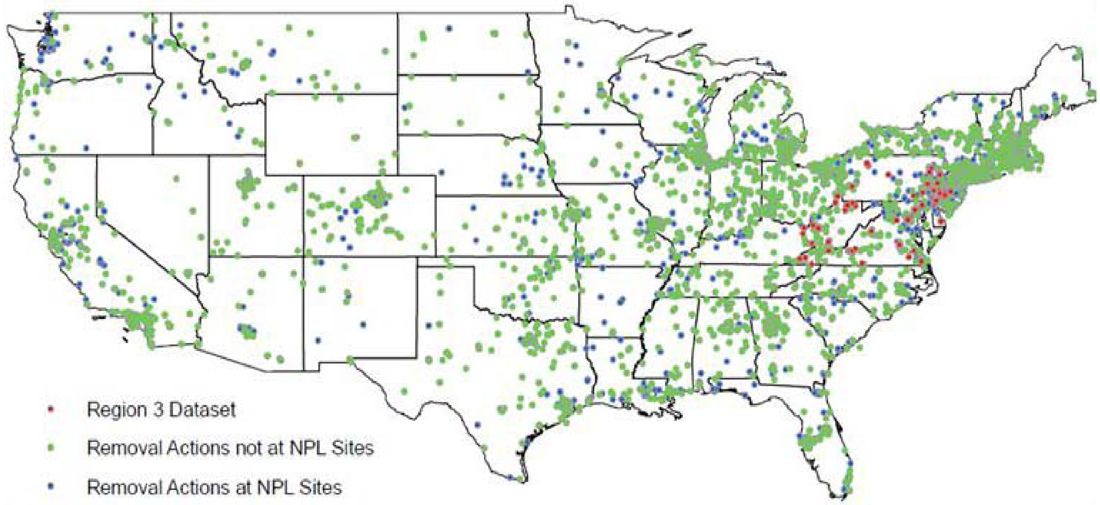
Source: GAO (2008).
Note: These data exclude reimbursable expenditures and other expenditures related to the Brownfields program, transfers to other EPA appropriations, and the 2002 Homeland Security Supplemental appropriation. Other Superfund expenditures related to homeland security are included in various categories. The level of expenditures in each category—but not the total—could vary based on whether certain costs are classified as administration-related.

2.3 The ERR Program Nationwide

At present, EPA has conducted or overseen more than 8,300 removal actions at about 5,300 sites. Threats at a majority of those sites (78 percent) were addressed with only one removal action, but complex sites can require multiple removal actions. The annual number of EPA-led removal actions averaged 141 per year during the 1990s and169 during the 2000s. Actions led by other federal agencies or PRPs, averaged 82 annually during the 1990s and 172 during the 2000s (U.S. EPA 2010e). During the 1990s, the most common actions were time-critical removals; emergency responses made up the second-largest category, and non-time critical removals the smallest (Probst and

Konisky 2001). Figure 2 shows the locations of removal actions nationally, highlighting in blue removal actions at NPL sites, and in red removal actions included in our data set. The majority of removal actions have taken place in the Northeastern and Midwestern United States.

Figure 2: Locations of EPA Emergency Response and Removal Actions, 1981 – 2010*



* The CERCLIS database does not contain coordinates for approximately 8 percent of the removal actions.
Source: U.S. EPA 2010e

Removal actions vary according to location, contaminants, health risks, population density, and a host of other considerations. Examples of releases range from contaminants spilled by a train wreck, during a hurricane, or as a result of terrorism, to a freshly uncovered old cache of lead paint cans. Depending on site-specific circumstances, sometimes nearby residents are evacuated or provided alternative drinking water. Other times, air is tested, or barrels of hazardous substances or acres of topsoil are removed. The next section describes our data set, which contains a rich variety of removal actions.

3 Region 3 and Dataset

To better understand the ERR Program we examined a set of recently addressed removal sites in EPA Region 3. This section describes the characteristics of Region 3, explains the data collection effort, and concludes with a summary of the sites within our sample.

3.1 Description of Region 3

EPA Region 3 includes Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and the District of Columbia. Due in part to the early presence of iron, steel, coal, and other manufacturing industries, Region 3 has a history of responding to hazardous waste contamination and environmental emergencies. Under authority of the NCP and the Clean Water Act, in the early and mid-1970s, Region 3 helped clean up a number of tanker accidents on the Delaware River and damages from tropical storm Agnes involving hundreds of thousands of gallons of oil and chemicals. In the later 1970s, the region also responded to hazardous waste emergencies such as the PCB contamination of a warehouse in Youngsville, Pennsylvania (U.S. EPA 2010f).

Since the passage of CERCLA, Region 3 has operated an active ERR Program. To date, the Program has completed nearly 920 removal actions (U.S. EPA 2010e). Several states in the region oversee and fund their own state remedial and ERR Programs. For example, Pennsylvania's 1988 Hazardous Sites Cleanup Act (HSCA) authorized the state's Department of Environmental Protection to eliminate threats to public health and the environment from hazardous substances through removal and remedial actions (PA Department of Environmental Protection 2010a). As of October 2009, nearly 200 response actions had used the state's HSCA funding (PA Department of Environmental

Protection 2010b). Delaware also conducts response actions under authority granted by its 1990 Hazardous Substance Cleanup Act to clean up sites not addressed under the federal ERR Program (Delaware Department of Natural Resources 2010).

3.2 The Data Collection Effort

The starting point for our data collection effort was a recent EPA land use assessment of sites within Region 3 where removal cleanup activities were completed between January 1, 2001 and October 1, 2006 (U.S. EPA 2007). The assessment identified 109 removal sites encompassing a total of 766 acres, with 93 sites and 463 acres occurring on non-NPL sites, and 16 sites and 303 acres occurring on NPL sites. Some of the sites had more than one removal action; federal facilities were excluded from consideration.

Because it could prove difficult to separate the potential impacts from removal and remedial actions occurring at the same site, we limited our study to the non-NPL sites identified in the EPA Region 3 report. For each site we gathered information about the causes of contamination, the nature of involvement by EPA and PRPs, the types of contamination and risks found, and detailed information about the cleanup process, including the timeline of assessment and removal activities, cleanup costs, and information sharing with the public by EPA and other sources.

We first reviewed the paper files in the Region 3 office for each site. Most of the data items we were looking for are intended to be covered in the Pollution Reports filed by OSCs for each removal action. However, we found the contents and scope of the files varied substantially among sites so we gathered more information by searching on-line resources such as the Region 3 website, the EPA Headquarters website for the ERR

Program, the EPA Comprehensive Environmental Response, Compensation, and Liability Information System database (CERCLIS), and relevant state environmental office websites.

The Agency for Toxic Substances and Disease Registry (ATSDR) Region 3 office also shared their Records of Activity, Health Consultations, and Public Health Assessments for sites when available, providing information about site history, contaminants, and potential health risks prior to the completion of removal activities. When paper and on-line records were unclear or contradictory, we sought clarification from contacts in the Region 3 Hazardous Site Cleanup Division. These data were supplemented by examining press releases and over 20 local newspapers through LexisNexis Academic, Google, GoogleNews, and the archives of pertinent local newspapers. We had greater difficulty finding articles about rural sites located in or near towns with newspapers that do not archive their articles or that require a subscription to access the archives.

3.3 Summary Statistics

The final dataset represents Region 3 sites with final removal action Pollution Reports completed during the timeframe of January 1, 2001 - October 1, 2006 and with removals started in 1996 or later. This covers 113 removal actions on 88 sites across 432 acres.[5] Table 1 shows the breakdown of the number of actions, sites, and acreage by state. The majority of the removal activities in our dataset occurred in Pennsylvania and Virginia, the largest and most populated states in Region 3, followed by West Virginia.

[5] Five of the 93 sites reviewed in U.S. EPA (2007) fell outside the study period, leaving 88 sites.

Note that our dataset is not necessarily a nationally representative sample of removal actions.

Table 1: Removal Actions in Region 3 Dataset by State

State	Number of Removal Actions	Number of Sites	Number of Acres*
District of Columbia	6	6	17
Delaware	7	7	37
Maryland	3	3	5
Pennsylvania	52	36	204
Virginia	23	20	98
West Virginia	22	16	72
Total	113	88	432

*Acreage is unknown for 9 sites (5 in PA, 3 in VA, and 1 in WV).

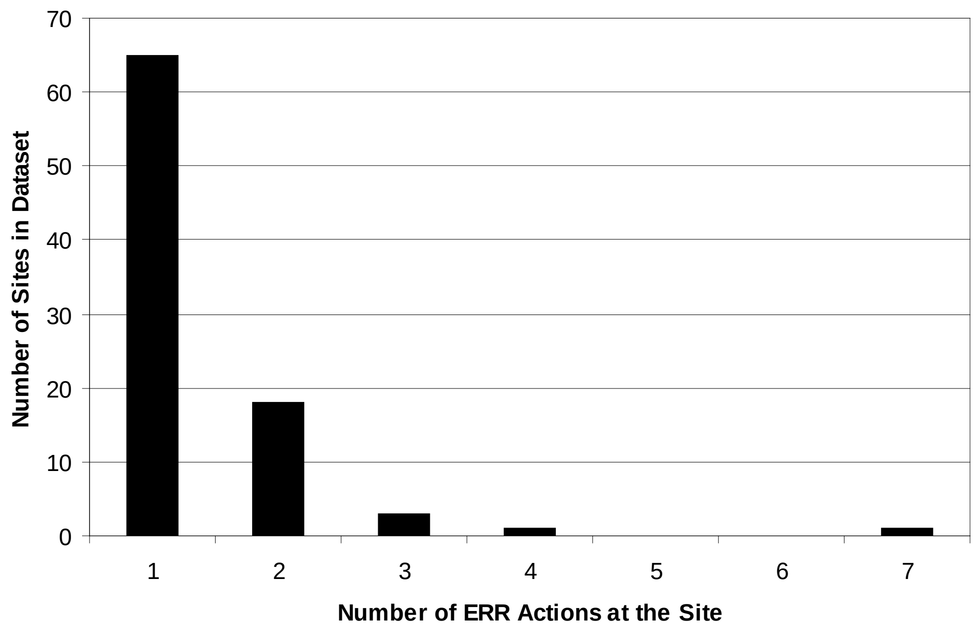
The sites are frequently located in populated areas. Table 2 shows that 80 percent of the sample sites are in urban or suburban areas or towns. Many were the result of contamination from old salvage yards, dumps, or former manufacturing facilities in areas that are now residential, commercial, or in continued industrial use. Others were a result of accidents or bio-terrorism. We discuss the nature of the contamination and the removal activities in our sample in more detail in the next section.

Table 2: Nature of Site Location in Region 3 Dataset

State	Urban	Suburban/ Town	Rural	Total
District of Columbia	6			6
Delaware	4		3	7
Maryland	2		1	3
Pennsylvania	10	20	6	36
Virginia	5	11	4	20
West Virginia	1	12	3	16
Total	28	43	17	88

There is an important distinction between removal sites and actions. Removal sites are defined in the CERCLIS database and typically refer to continuous geographic areas where cleanup activities occurred. Actions refer to the measures taken to address the contamination. It is quite common (18 of our 88 sites) for multiple removal actions to occur at a single site. Figure 3 presents the frequency of a total 121 removal actions for our sample of 88 Region 3 sites. In most cases these actions are linked not just by geographic location but also by the source of the contamination. For example, an initial removal action might stabilize the situation before subsequent actions achieve a more permanent cleanup.

Figure 3: Frequency of Multiple Removal Actions at Sites, Region 3 Dataset



It is also possible for removal actions at different sites to be linked through a common history. For example, battery manufacturing in Hamburg, Pennsylvania, resulted in extensive lead contamination throughout the town caused by smoke from the plant's smelter and the use of battery casings as infill. While the battery plant was listed on the NPL in 2005, removal actions at 9 other sites throughout Hamburg have taken place since 1993 to address imminent hazards. Since we do not have detailed information on Region 3 removal actions outside our sample time frame, it is not possible to fully characterize the extent of such linked actions, but we are aware of at least 18 sites in our dataset where the incident resulting in the contamination also led to a removal action at another site.

4 Contamination and Cleanup at Sample Removal Actions

This section examines the characteristics of the removal actions within our sample of Region 3 sites. We begin by looking at the causes of the contamination and the role of the EPA and PRPs in the cleanup response. This is followed by a detailed discussion of the contaminants of concern and the risks they posed to public health. We conclude by describing the cleanup actions used to address these risks as well as communications with the public.

4.1 Causes of Contamination and Involvement by EPA and PRPs

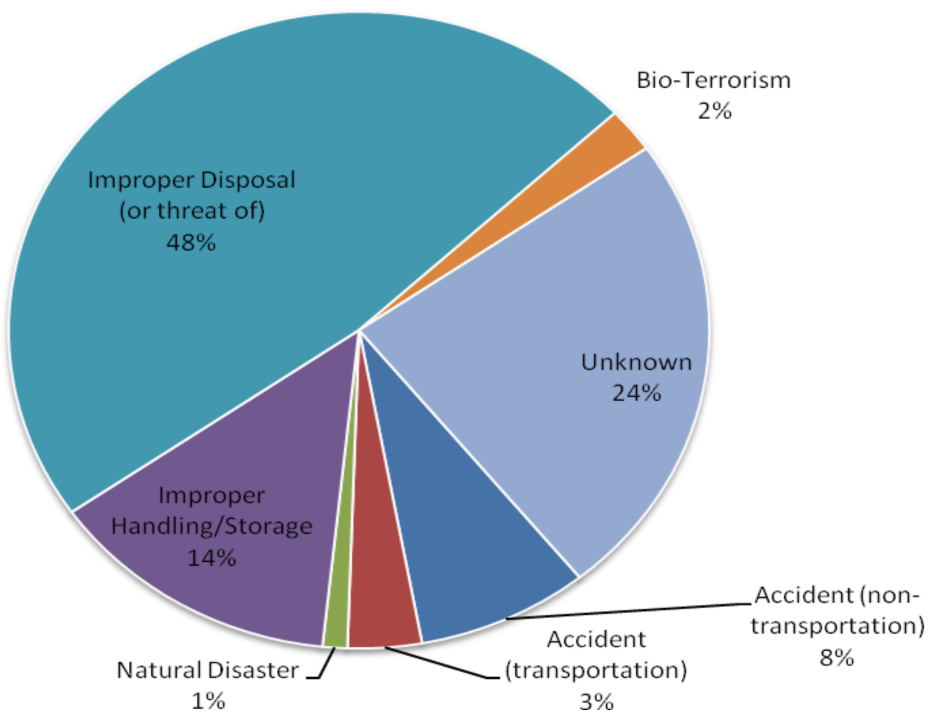
A wide variety of events can cause or threaten contamination leading up to a removal action, just as a wide variety of sources can initiate EPA involvement. The parties responsible for the contamination are liable for the cleanup costs and they may be allowed to lead the cleanup, as we explain below.

4.1.1 Events Causing or Threatening Contamination

Each removal action has its own unique story regarding the events triggering or threatening the release of hazardous substances and leading up to federal intervention.

The incidents responsible for contamination can be broadly characterized as accidents, natural disasters, improper handling and/or storage, improper disposal, and bio-terrorism. Figure 4 presents the distribution among these categories for our set of 88 sites.

Figure 4: Events Threatening or Leading to Contamination at Region 3 Sites, 2001-2006



The most common reason for the release or threatened release of hazardous substances was the improper disposal of materials. In a number of cases, improperly buried waste leached hazardous substances into soil and/or groundwater. In other instances, firms simply abandoned facilities and failed to properly dispose of hazardous materials for reasons such as bankruptcy. This was the case at the Evans Chemical manufacturing facility in Virginia, which was abandoned in 1992 along with hundreds of drums leaking highly toxic substances.

The second leading cause of contamination was improper handling and/or storing of hazardous materials. Many of these cases involved hazardous materials that the owner planned to use in the future that were stored in deteriorating or uncovered drums. In a few instances, students stole mercury from school labs, causing spills that exposed other students, teachers, and their families.

Accidents were another cause of contamination, often related to the transportation of hazardous materials by rail or truck. The Kelly Drive removal action in Pennsylvania was precipitated by a train derailment in which two rail cars upended and began to leak sulfuric acid.

Only one incident in our sample was the result of a natural disaster. In 2004, Hurricane Gaston flooded Richmond, Virginia, with over 14 inches of rain in a two hour period, causing four barrels of oil to leak into the James River. Nearly as rare but particularly noteworthy were two highly publicized bio-terrorism cases involving ricin and anthrax mailed to Congressional office buildings in Washington, D.C.

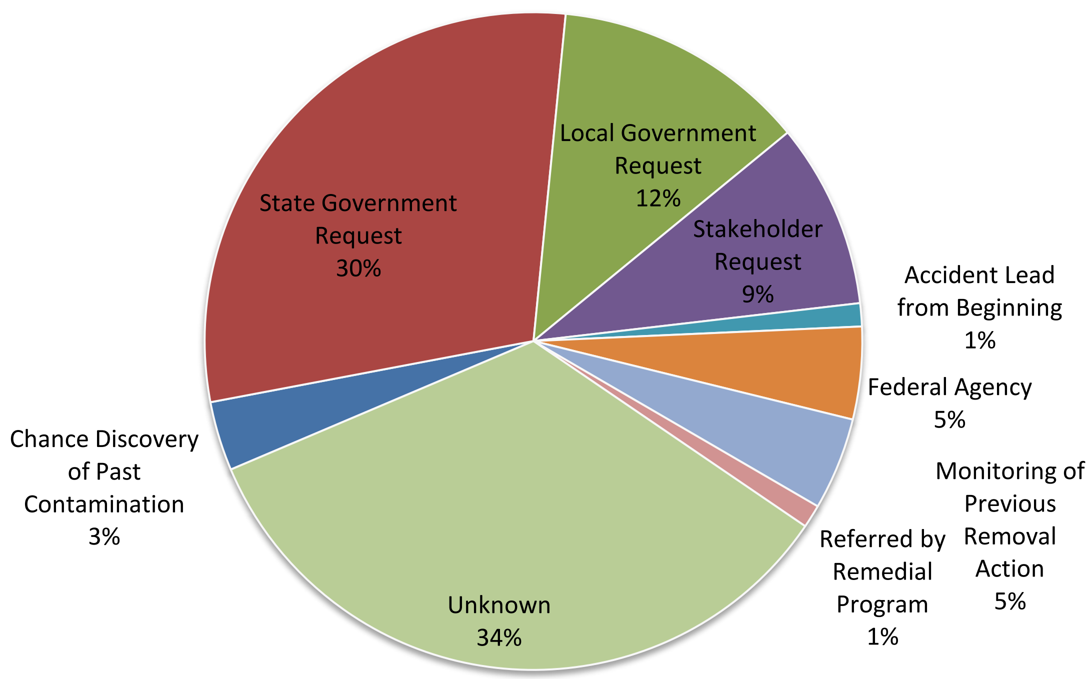
4.1.2 How the EPA Became Involved

There exists a distinction between the time that the contamination, or the threat of, was discovered by a concerned party and the time at which the EPA became involved with the cleanup efforts. Within our subset of Region 3 removal actions there are only a few cases where the EPA was in control from the time of discovery. In most instances the EPA became involved as the result of concerned parties reaching out to the agency.[6] Concerned parties contacting the EPA include state and local government, responsible parties, and concerned citizens. In other cases the EPA became aware of the contamination as a result of monitoring at a previous removal action or by chance

[6] In some cases the EPA was contacted directly by the concerned party, while at other times the concerned party initially contacted the National Response Center who then relayed the information to the EPA. In this section we treat the latter to be equivalent to contacting the EPA directly due to a lack of information allowing us to differentiate between the two cases.

discovery. In one instance the site was referred to the ERR Program by the Remedial program. Figure 5 presents a chart for the sites in our sample summarizing how the EPA became aware of the contamination requiring a removal action. As may be seen, there was not enough information to determine how the EPA became involved for around a third of the actions.

Figure 5: How EPA was Informed of the Contamination at Region 3 Sites, 2001-2006



For the cases where information was available, the most common way the EPA became involved was through a request from a state agency. Direct requests from local government affiliates were also fairly common among our sample of Region 3 removal action. At three of the sites it was the Philadelphia Department of Licenses and Inspections that first discovered the contamination. Afterwards the City of Philadelphia contacted both the EPA and the Pennsylvania Department of Environmental Protection at the same time. In the case of the Kelly Drive train derailment, discussed earlier, the Philadelphia Emergency Operation Center contacted the EPA directly after surveying the situation. In other instances the EPA was contacted directly by school districts, local fire departments, and municipal water authorities.

Almost as frequent as requests by local authorities were requests directly from stakeholders. These requests were typically from citizens concerned about potential contamination. For example, at the Hamburg Broom Works site a concerned citizen noticed exposed battery casings in a vacant lot where children frequently played; given the potential for lead contamination, they subsequently contacted the EPA. At the Starlight Lane Tire Fire in Virginia, a concerned citizen contacted the EPA when a brush fire reached a scrap yard containing three to five million used tires. In one instance a private remediation firm notified the EPA of groundwater contamination at a site which it did not own.

In other cases the EPA was informed of the contamination by other federal agencies such as the Nuclear Regulatory Commission or U.S. Fish and Wildlife Services. Contamination at two of the sites was discovered by chance through unrelated EPA activity at adjacent sites. For example, while involved with the removal action at the 12th Street Dump site in Pennsylvania the EPA discovered oil contaminated sediment on the tidal mudflat of the Brandywine Creek. This discovery led to further testing and eventually a separate removal action. In four different instances the removal actions were triggered by EPA monitoring of contamination levels at prior removal sites

4.1.3 Involvement of Potentially Responsible Parties

While EPA maintains authority during all removal actions, the intent of CERCLA is for responsible parties to fund and implement the cleanup, when possible. As shown in Table 3, PRPs were identified at 52 of the 88 sites in our dataset. Out of these 52, the PRP led all removal actions at 24 of those sites, and at least one action at another 14 sites.

Table 3: PRP Involvement at Removal Sites, Region 3 Dataset

	Number of Sites	
PRP(s) Identified	52	
Full PRP-led		*24*
PRP-led at least one action		*14*
Full EPA-led		*14*
No Identifiable PRP	36	

When a PRP is identified, EPA can issue a special notice letter to solicit a good faith offer from the party to conduct or finance the removal action. This process triggers a 60-120 day moratorium on EPA cleanup activities, during which EPA works with the PRP to develop a legally binding administrative order detailing the cleanup steps and timeline. This was the case at the Absco Scrap Yard site in Philadelphia, Pennsylvania. The site was long used as a scrap yard and had once been a rail yard. After half a century of industrial use the soil at the site had become contaminated with PCBs and lead. The EPA worked with the former owner of the scrap yard and the new owners of the property to negotiate a settlement in which the PRPs funded and led the removal actions necessary to clean up the site to a point where reuse was safe.

As a 60-120 day moratorium on action may pose unnecessary risks to the community at sites warranting more immediate action, the region may waive the use of special notice and issue general notice letters which will set more urgent deadlines for the

PRPs to state their willingness to undertake the cleanup action. If PRPs exist but do not reach a settlement with EPA by the end of the established deadlines, EPA can issue a unilateral administrative order to compel the private parties to complete the cleanup. Under CERCLA section 106(b)(1) any party that violates a unilateral order without cause may be subject to fines of up to $25,000 a day during the period of the violation. Such unilateral orders provide a credible threat to encourage settlement and cooperation. If however, the unilateral order fails to encourage action by the PRPs the EPA may consider judicial action to compel cleanup or precede with a fund-financed removal action. If the Agency chooses to finance the action it is able to recover costs in addition to punitive damages from one to three times the costs expended as authorized by CERCLA section 107(c)(3). Unilateral administrative orders were issued at 10 of the 52 sites in our dataset where a viable PRP was identified.

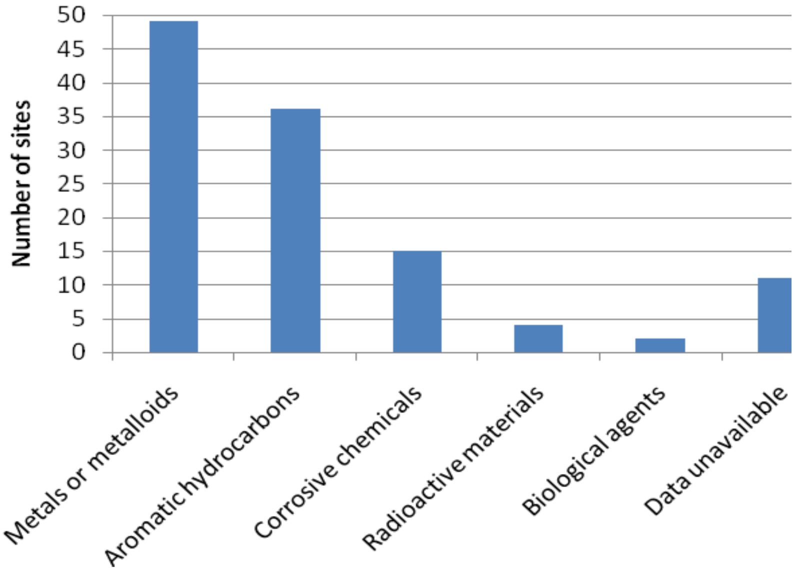
The situation on the ground does not always permit EPA to work with the PRPs to develop a mutually acceptable agreement while preserving limited fund resources. When contamination poses an imminent threat, EPA may undertake the removal action itself, and then seek reimbursement for cleanup costs. The statute of limitations for cost recovery is three years for removal actions, however under certain exceptions this may be extended to six years under CERCLA section 104(c)(1)(C). Alternatively, a PRP may engage in a removal action without an administrative order on consent or other enforceable instrument in place. This type of action occurred at 11 of the PRP-led sites in our dataset. In ten of those cases this represented the only removal action to take place at the site. The other site was the Kelly Drive Sulfuric Acid spill in Philadelphia, Pennsylvania, where 12 railcars containing sulfuric acid derailed leaving two cars laying on their side and leaking. The PRP mobilized its own response team which began neutralizing contamination with lime, while retrieving free-standing liquid using vacuum truck pumps. While this initial removal action stabilized the site, there remained a need for the PRP to conduct a second removal action in which the contaminated soil was excavated and properly disposed.

In the absence of an identifiable and viable PRP, the role of leading and financing the cleanup falls to EPA. At 36 of the 88 sites in our dataset, there is no indication of a PRP being found that could be held liable. For example, at the Cosmechem site in Baltimore, Maryland, police responding to a burglary found hazardous materials in drums and bags at an adjacent abandoned property previously belonging to a wholesale chemical distributing company that had long been dissolved. Given the need to eliminate the health threat the EPA itself removed and disposed of over 5,300 pounds of hazardous materials.

4.2 Contamination and Risks

A diverse array of chemicals and hazardous substances contaminated removal sites in our dataset, raising potential risks for surrounding populations and ecosystems. Figure 6 provides a breakdown of contaminants at the Region 3 sites by broad chemical classes. Thirty-four sites contained more than one contaminant.

Figure 6: Contaminants Found at Removal Sites Prior to Cleanup, Region 3 Dataset



The most common contaminants out of more than 50 substances identified at the sites included lead, mercury, and other metals and metalloids; polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and other aromatic hydrocarbons; and corrosive chemicals such as sulfuric acid. These chemicals present a spectrum of health risks ranging from cancer to major organ damage to developmental disorders. Over half of the sites in the dataset contained at least one carcinogen, such as arsenic, chromium, PCB, trichloroethylene (TCE), or sulfuric acid. The data also reveal less common but still notable hazards such as radioactive materials and the biological agents anthrax and ricin.

This heterogeneity in contaminants is echoed in the variety of contaminated environmental media across removal sites. Table 4 shows that out of the 76 sites for which information is available, soil was the most frequently contaminated medium. However, air, groundwater, and surface water contamination were also prevalent at removal sites. Indeed, some of the program's most urgent cases involved health risks via an air pathway, including the anthrax, ricin, and mercury incidents, and fires at industrial and commercial sites.

Table 4: Actual and Potential Media Contamination Prior to Cleanup at 76 Region 3 Sites

	Number of sites
Actual media contamination*	76
Soil	*51*
Surface water	*30*
Groundwater	*10*
Air	*24*
Contained contaminants	*22*
Potential spread to additional media	31
Actual or potential risk of fire or explosion	19
Data unavailable	12

*44 of the 76 sites had actual contamination in more than one media.

In 22 cases, contaminants were not released to the environment, but remained contained in drums, paint cans, or other containers. For example, Cobalt-60, a radioactive material, was found in a reactor pool and transfer cask inside a former research and industrial facility located in a remote area of Pennsylvania's Moshannon State Forest. Absent cleanup, this material threatened recreationalists with dangerous levels of radiation.

In addition to addressing actual contamination at all sites, removal actions eliminated the threat of contamination spreading to additional media at 31 of the Region 3 sites. These cases include those where contained contaminants had not been released, as well as several sites with soil contamination that could have migrated to nearby groundwater or surface water. A different threat at 19 sites was the potential for fire or explosion caused by flammable or ignitable materials. The risks posed included hazardous airborne releases reaching many more people than those coming into direct contact with on-site contaminants.

A completed exposure pathway depends not only on the presence of contaminants in environmental media, but also on human contact through inhalation, ingestion, or dermal absorption. For many of the Region 3 sites, information is unavailable about the actual route of exposure to contamination, how many individuals (if any) were exposed, and at what levels. Table 5 attempts to provide a qualitative picture of the types of health risks that removal actions may have helped mitigate. The table presents the four most common exposure pathways of concern at the 73 sites for which information was available. It is worth noting, however, that a focus on individual exposure pathways could obscure potential interactions among multiple pathways, which are present at many sites.

Table 5: Most Common Exposure Pathways Prior to Cleanup at Region 3 Sites

Contaminant	Medium	Potential exposure route	Residential/ industrial screening level*	Median concentration at sites [range]**	Number of sites
Lead	Soil	Ingestion	400/800 ppm	9975 ppm [100 – 522,000]	27
PAHs***	Soil	Inhalation, ingestion	0.015/0.21 ppm	37 ppm [5 – 220]	9
Mercury	Air	Inhalation	0.31/1.3 $\mu g/m^3$	55 $\mu g/m^3$ [19 – 100]	7
PCBs	Stream sediment	Ingestion of sport fish	0.22/0.74 ppm	11 ppm [0.37 – 1580]	6

* The Region 3 screening levels represent “chemical-specific concentrations for individual contaminants in air, drinking water and soil that may warrant further investigation or site cleanup” (U.S. EPA 2008). Screening levels are not cleanup standards. They are also nonbinding and can vary from site to site. Screening levels are based on human health considerations and do not consider ecological effects.
** For sites where more than one sampled concentration level was available, the highest level was used to determine the median and range across sites. Sampling data were unavailable for 1 lead site, 5 PAH sites, and 2 mercury sites.
*** The reported PAH screening level and sampled concentrations are for benzo(a)pyrene, considered to be among the most toxic and well-studied PAH compounds (ATSDR 2010a).

Exposure to lead-contaminated soil through ingestion was the most common potential pathway. Incidental ingestion is the typical exposure route of concern, especially for young children who play outside. Intentional ingestion is rare but still another possibility that raises alarm at sites where children play (ATSDR 2007). In at least one case (Philadelphia's Logan neighborhood), consumption of vegetables grown on-site was a potential means of ingestion. Lead can damage major organs, reproductive function, and especially the central nervous system. Children, in particular, are vulnerable to cognitive and neurobehavioral impairment (ATSDR 2007). Adults are vulnerable to hypertension and cardiovascular effects (Navas-Acien, et al. 2007).

Soil sampling data reveal that most lead-contaminated sites substantially exceeded EPA's screening level. At removal sites in Hamburg, Pennsylvania, lead in the soil reached concentrations in the tens of thousands of parts per million. While the precise exposure and health impacts are unknown at these sites and causal relationships cannot be established, 17 percent of children in the Hamburg zip code who were screened for lead between 1998 and 2004 had blood levels of at least 10 µg/dL (ATSDR 2010b), compared to a 9 percent statewide average over the same period (CDC 2010). The Centers for Disease Control considers interventions where children's blood lead levels exceed 10 µg/dL, although levels less than 10 µg/dL are associated with decreased IQ in populations evaluated in epidemiological studies (ATSDR 2007). At the Arthur Road Duplex site in Reedsville, West Virginia, contaminated sand used as fill caused soil lead concentrations of almost 5000 ppm at a residential property where young children lived. ATSDR (2006) estimated that exposed children could have experienced blood lead levels ranging from 3.1 to 24.9 µg/dL, depending on the number of days spent playing on the soil, the amount of soil tracked inside the home, and the age of the child, with toddlers significantly more vulnerable than older children.

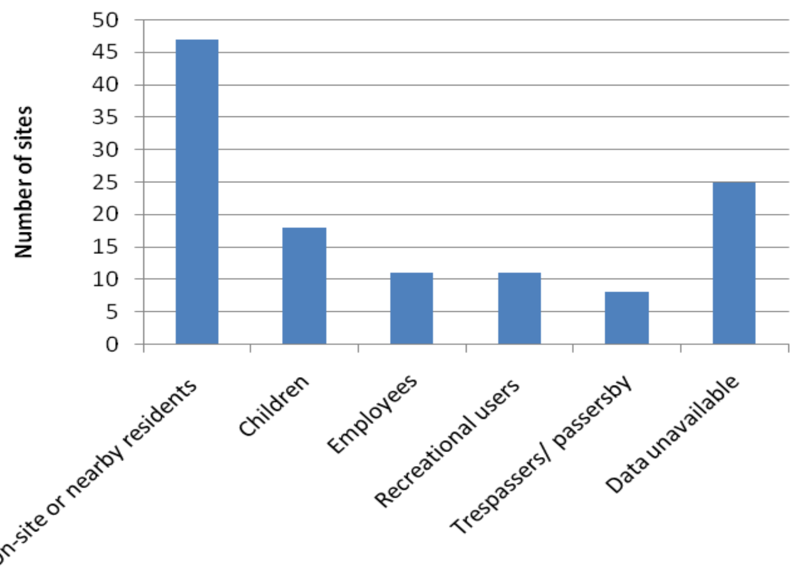
Ingestion or inhalation of PAHs in soil or dust was another relatively frequent pathway. PAHs are a group of over one hundred compounds, several of which are carcinogens. Concentrations of benzo(a)pyrene, one of the most toxic and well-studied PAHs, reached high levels at the four sites where data are available. At the Dalzell Viking Glass Company site, ATSDR (2010a) estimated that lifetime cumulative exposure for nearby residents to benzo(a)pyrene (found in the soil at 5 ppm) and other PAHs could yield a theoretical excess cancer risk of 1 in 10,000.

Exposure to elemental mercury released by spills occurred at seven sites, including two high schools and a college. At a residence in Hatboro, Pennsylvania, a mercury spill caused acute poisoning and hospitalization for all members of the household, including five children. Mercury poisoning typically causes renal and neurological damage through inhalation of mercury vapors (Risher 2003), though acute exposure can also lead to skin and eye irritation; cardiovascular, gastrointestinal, and respiratory impairment; and even death.

Sediment contaminated with PCBs—a group of chemicals that are probable carcinogens and can cause reproductive and development disorders—was found in streams or tributaries at several sites. The primary pathway of concern was consumption of sport fish. For example, runoff from sandblasting pools at the Warwick Township Real Estate site in Bucks County, Pennsylvania, led to PCB contamination in a nearby popular recreational fishing creek. Screened sport fish tissue samples revealed PCB contamination above levels of concern (ATSDR 1999, 2000a). While a removal action was undertaken to eliminate the source of contamination, the Pennsylvania Department of Public Health also recommended a temporary fish consumption advisory for carp and other sport fish. Meanwhile, contamination did not reach levels considered a public health risk at all sites. PCBs migrating from the Diamond State Salvage site to Brandywine Creek in New Castle County, Delaware, were identified in stream sediment at a maximum concentration of 0.37 ppm, and ATSDR (1998) found no evidence of sufficient fish consumption to raise alarm.

These examples of common exposure pathways highlight the different groups of people who might have been exposed to contaminants. Figure 7 illustrates the populations who were actually or potentially exposed across the Region 3 sites, including residents and recreational users. Employees at businesses located at or near removal sites were often at risk, including workers at industrial facilities, teachers at schools with mercury releases, and staff in Congressional office buildings where the bioterrorism incidents occurred. Contaminants also posed threats to trespassers or simply travelers passing by, as in the Kelly Drive sulfuric acid spill, which affected a roadway in Philadelphia. Evidence of an actual or potential threat to children, whether at school, daycare, or playing at home, was documented at 17 sites. Children are of particular concern because they face different risks and exposures and may respond differently to contaminants than adults (U.S. EPA 2003).

Figure 7: Actual and Potential Exposed Populations at Region 3 Sites*



*Actual and potential exposed population categorization is based on the authors' interpretation of Pollution Reports and other OSC-prepared documents.

According to data from the 2000 census, the block groups containing the sample removal sites were not significantly different from the average characteristics in Region 3 in terms of race and the proportion of children under five years old. Block groups with removal sites did have a significantly lower percentage of renters, a lower proportion of children between ages five and seventeen, and a lower median income, according to t-tests at the 5 percent significance level. Table 6 compares the average characteristics of the block groups with sample removal sites with Region 3 as a whole.

Table 6: Demographic Characteristics of Census Block Groups

	Average for Block Groups with Sample Removal Actions	Average for Region 3 Block Groups	P-value
% Non-white	24%	24%	0.88
% Under age 5	6%	6%	0.15
% Age 5 – 17	16%	18%	0.018*
% Renter households	32%	45%	1.5E-06*
1999 Median income	$36,041	$44,796	6.1E-05*
Number of block groups	79	21337	

* denotes significant difference at the 5 percent significance level according to t-test.
The number of block groups with sample removal actions is less than the total number of removal actions due to the presence of multiple removal sites in some block groups.

Sites addressed by the ERR Program can threaten not only human health, but also ecosystems. Many sites are located on undeveloped land or near surface water that provides habitat for wildlife. Contaminants sometimes inflict similar adverse impacts on wildlife as they do on people. For instance, lead ingestion leads to immunological, neurological, reproductive, developmental, and carcinogenic effects in animals as well as humans (ATSDR 2007). In fact, lead contamination, mainly from lead shot, is a leading cause of mortality for wild birds (USGS 2009). In Harbeson, Delaware, birdwatchers chanced upon dozens of dead or injured swans suffering from lead poisoning caused by the use of the site as a former skeet shooting range, prompting a removal action to address contaminated soil and water.

Actual or potential hazards to animals or ecosystems were documented at 15 sites, including the sites with PCB-contaminated fish, as well as five sites with fish kills or other animal deaths. Potential contamination was a concern at additional sites located near sensitive habitats, domesticated animals, wildlife, or recreational areas.

4.3 Cleanup Actions

Cleanup activities and costs at removal sites are quite variable, reflecting the wide variety of contaminants found there. The time required to complete cleanup activities is most frequently less than six months in our Region 3 sample, but can be much longer as we will see below.

4.3.1 Types of Removal Actions

Given the tremendous heterogeneity in exposed populations, contaminants, and triggering events in Region 3, it is not surprising that a wide array of cleanup approaches was used during removal actions. Out of 60 sites for which some data on cleanup actions were available, the most prevalent types of activities were the removal of contained contaminants and debris (39 sites) and actions addressing contaminated soil (37 sites). Chemical spills, contaminated groundwater, surface water, or air pollution were addressed at more than ten sites in the sample. There is also diversity in the activities used to target each type of media. The cases of groundwater, soil contamination, and air pollution provide good examples to highlight this heterogeneity. There exists slightly more homogeneity in the cleanup actions taken to address surface water contamination.

Cleanup activities explicitly addressed groundwater at 12 sites in the dataset.[7] In many cases these activities were designed to address potential future groundwater contamination. For example, at the National Vulcanized Fiber site in Chester County, Pennsylvania, contaminated soil beneath the firm's retention pond was disposed of while a new liner was installed to prevent future groundwater contamination. At the I-81 Tractor Trailer Chemical Spill in Augusta County, Virginia, storm water drainage systems were pumped in order to prevent future contamination of groundwater.

A typical ERR Program response to groundwater contamination is to provide residents with clean drinking water. Residents are typically supplied with bottled drinking water until access to safe drinking water can be restored via connection to public water supplies or by having proper filtration equipment installed on their wells (U.S. EPA 2000b, Probst and Konisky 2001).

The actual cleanup of contaminated groundwater during removal actions is rare due to the time required for the pump and treat process to be successful. Sites where this type of action is necessary might instead be referred to the Superfund Remedial program.

[7] Note that just because removal actions did not address groundwater explicitly at all sites with potential groundwater contamination does not mean it was neglected. Often addressing current soil contamination, for example, can help prevent future groundwater contamination.

However, two removal actions in our sample involved groundwater cleanup – at one, the time required for treatment to be successful was relatively short; at the other, rapid treatment was not a practical option. At the Village of Reeders site in Monroe County, Pennsylvania, residents contacted the EPA to report a foul odor associated with their drinking water. A number of heavy metals and other contaminants were found in the groundwater. Residents were provided with bottled water until a safe drinking water supply could be restored when activated carbon filtration systems were installed in the affected wells. In Glendale, West Virginia, an underground storage tank began leaking trichloroethylene into the groundwater used by the town's residents. An air stripper was installed to decontaminate the water supply. As this treatment approach would require nearly three years to achieve safe drinking water levels, it was necessary to install a new well to supply the town with water in the meantime.

Similar diversity may be found in the cleanup actions addressing soil. At 37 sites in our sample information on the type of soil cleanup was available, including cap and containment actions, onsite treatment, or offsite treatment. As shown in Table 6, some type of cap and containment action occurred at 15 sites.

Table 6: Soil Cleanup Actions at Region 3 Sites, 2001-2006

Type of Cleanup Action	# of Sites	% of Sites
Cap and containment	15	17%
Onsite treatment	1	1%
Excavation and Disposal or Treatment Offsite	32	36%
Other	5	6%
Total*	37	42%

*Data on the type of soil cleanup performed were only available for 37 out of 51 sites with soil contamination.

On-site treatment was unusual due to the difficulty of addressing most types of soil contamination in place and the typical lack of space or facilities for proper disposal.

However, it was feasible at the Motiva Enterprises site in New Castle County, Delaware. An explosion at the industrial facility released approximately one million gallons of sulfuric acid. Neutralizing agents such as lime and calcium hydroxide were mixed with the soil to counteract the contamination. These efforts were followed up with a soil cap and numerous efforts to reduce erosion and run-off.

More common was the use of excavation and offsite disposal or treatment of the contaminated soil. While the specifics of the process varied, the Irondale Lead Site in Wise County, Virginia, illustrates the general framework. In response to lead contamination in the soil that threatened local water systems, EPA excavated the soil and removed it from the site for proper disposal. Afterwards a soil cap was used to contain trace elements in the remaining soil. Soil caps are sometimes used without soil excavations as well. At the Dead Swan Site in Harbeson, Delaware, the land was capped and covered with pine trees to contain lead-contaminated soil and prevent erosion and run-off.

While air pollution is less often addressed in removal actions, there remains some variation among those sites where it is targeted. Eleven sites in our sample were the subjects of cleanup actions related to existing, or potential, air contamination. In two instances it was necessary to vent the pollution from an enclosed structure. This included the Cardozo High School site in the District of Columbia, where three students stole mercury from a chemistry lab and later released it in the school. At other sites such as the Capitol Hill Anthrax site in the District of Columbia, gaseous chlorine dioxide was used to kill the anthrax spores that were airborne. The treatment at the other sites is similarly specific to the characteristics of the location and the type of airborne contamination.

Notably, when addressing the fourth major media category, surface water, there exists slightly more homogeneity in the cleanup actions. At 12 sites in our sample actions were taken to target surface water contamination. In at least nine of those cases the contamination required the containment of spill or storm water, with possible removal or filtration. Other methods were employed at 5 sites. For example, at the Kentucky/West Virginia Coal Slurry Spill, an impoundment holding coal mine refuse slurry breached into an adjacent mine and subsequently entered into the areas' watersheds. In order to extract the slurry, filter dams were created to trap the material for removal. In addition the slurry in small creeks was solidified and subsequently removed.

4.3.2 EPA Expenditures on Removal Activities

For 83 out of the 88 sites in our dataset we were able to obtain information regarding EPA's expenditures on removal actions. These numbers represent gross expenditures and are not net of any subsequent cost recovery from PRPs. They also do not contain information on spending by PRPs on cleanup, which can occur even at EPA's fund-led sites. Therefore these values do *not* represent the holistic cost of cleanup for a site.

Table 7 presents summary statistics for EPA expenditures per site in our dataset. The median EPA spending at a site was $338,000 (2008 dollars) while the average was much higher due to a number of outliers including the Capitol Hill Anthrax Site, which required expenditures of over $52 million. The median cost to EPA of sites with multiple removal actions was almost twice as much as those with only one action. For sites where all removal actions were PRP-led and financed, median EPA expenditures were $111,000 per site for payroll, travel, assessment, and other costs. Median costs to EPA at sites with soil and groundwater contamination and contained contaminants were higher than those with surface water or air contamination or the risk of fire or explosion.

Table 7: EPA Expenditures per Removal Site, Region 3 Dataset (Thousands of 2008$)

	Number of Sites	Average	Median	Min	Max
All Sites	83	$2,127	$338	$0	$52,443
With 1 Action	60	$2,382	$231	$0	$52,443
With >1 Action	23	$1,462	$436	$43	$8,874
Fully PRP-Led	21	$173	$111	$0	$658
Soil Contamination	49	$2,191	$620	$43	$20,397
Surface water Contamination	27	$2,121	$386	$41	$20,397
Groundwater Contamination	9	$548	$524	$25	$1,263
Air Contamination	23	$3,008	$306	$43	$52,443
Risk of fire or explosion	22	$513	$242	$40	$2,152
Contained contaminants	22	$1,567	$766	$40	$8,874

4.3.3 Length of Removal Actions and Information Sharing

We also gathered information on the length of removal actions. These data reflect the relatively quick remedies typically used during removal actions. Not considering assessment and design, the cleanup process took on average 19 months per action, with a median of 8 months indicating the presence of large outliers. The distribution of the length of actions in our dataset is broken down in more detail in Table 8. Thirty-six percent required more than a week but less than six months to complete. At the same time, our dataset contains many longer actions as well, including 27 percent that took over two years to complete.

Table 8: Length of Removal Actions, Region 3 Dataset*

Length of Removal Action	Number of Actions	% of Total
<1 week	4	4%
1 week - 6 months	40	36%
6-12 months	22	20%
1-2 years	15	14%
>2 years	30	27%
Total	113	

*For 2 of the 113 removal actions end dates were not available.
Percentages do not add up to 100 due to rounding.

Note these dates correspond to the time spent on the actual removal activities. They do not include site assessment, which can occur concurrently with removal actions or begin months or years beforehand. The date of discovery or the event that triggered the removal may have occurred months to years before the site assessment as well. For the 67 sites for which we have information on the entire timeline of events, the time from discovery of contamination to the start of the first cleanup action averaged nearly 9 months, but this is influenced by a few outliers that were over 4 years. The median time from discovery to the cleanup start was less than 3 months.

During a removal action, the type and frequency of communication with the public varies according to the length and urgency of cleanup. Longer and more complex actions typically involve more extensive communication efforts and sometimes even include a formal Community Involvement Plan based on community interviews. To inform the public, an OSC might hold meetings with local officials or the media, among other steps (U.S. EPA 2005b). For 36 of the sample sites, we located evidence of information sharing through news stories (30 sites), letters/fact sheets (20 sites), public meetings (10 sites), and press conferences (4 sites). While this provides some evidence that the public is informed, we hesitate to interpret the degree of public understanding regarding the precise nature and severity of risks present at removal sites.

5. Conclusions

The focus by the economics literature on measuring the net benefits of the Remedial Program, while neglecting the value of the ERR Program, may present an incomplete assessment of the Superfund Program. This paper seeks to motivate research in this area by providing an initial look into the ERR Program as illustrated by half a decade's worth of cleanup efforts in EPA's Region 3. The process of discovery, financing, and cleaning up removal sites involves a diverse number of stakeholders—from EPA to PRPs to state and other government agencies—responding to a large variety of contamination events. There is also tremendous diversity among the public health risks addressed by the program. The flexibility of the ERR Program to handle these hazards suggests that its benefits to society will arrive in many forms. Perhaps the ERR Program as a whole confers two levels of benefits – an aggregation of localized effects plus the insurance value of a national program that stands ready to address emergency contamination of almost any nature. The goal of this paper was not to quantify these benefits, or to provide a thorough assessment of the program's cost, but to explore the potential and provide motivation for future research into this important but often overlooked part of EPA's cleanup initiative.

In theory, risk assessment, hedonic property value, averting behavior, and even recreation demand models all offer potential approaches to estimate the benefits of removal actions, but they raise a variety of challenges. The relatively speedy nature of the cleanups, compounded by uncertainty about the extent of public awareness of and actual exposure to contamination, means it could be difficult to observe market transactions that meaningfully reflect the public's responses to contamination and cleanup. The heterogeneity of contaminants, exposure pathways, and cleanup approaches also pose difficulties for analysis. In addition, many of these sites are fairly small – less than 5 acres on average for the sample – thus, the geographic scope of effects might be limited and hard to measure. Still, further exploration of one or a set of these approaches might move us toward quantification of the benefits of removal actions.

Another unique characteristic of the ERR Program that complicates benefits assessment is that it addresses not only past contamination but also threatened releases of hazardous substances. We find that a significant portion of the program addresses the threat of fire or explosion and contained contaminants with potential for release. Addressing these types of hazards before they cause acute problems may be a more cost-effective method than waiting for exposure to occur before beginning cleanup. However, quantifying risk reductions associated with these actions is challenging because they depend on the probability that a fire, explosion, or release of chemicals would have occurred if the contamination was left unaddressed. In order to obtain a full picture of the benefits derived from the ERR Program the value of such risk reductions needs to be addressed.

Data availability is a challenge to describing both benefits and costs of the ERR Program. To paint even a partial picture of the benefits from removal actions, we found it necessary to examine a wide variety of data sources. A consolidation of information into OSC Pollution Reports or CERCLIS would help address this issue. To assess the ERR Program's net benefits, a more complete collection of cost data incorporating PRP expenditures would also be required. Still, the program's track record of quickly addressing immediate threats suggests that the present value of these net benefits is not likely to be diluted by long time spans between discovery of contamination and cleanup, as is sometimes the case with the Remedial Program which addresses complex contamination that often requires lengthy cleanups (Messer et al. 2006).

Finally, it is worth noting that, because of the prevalence of removal actions on NPL sites, previous estimates of the value of NPL cleanups may already include important benefits from the ERR Program. Future investigations into the value of Superfund cleanups would present a more balanced picture by identifying and accounting for removal actions that occur on remedial sites.

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