# An Evaluation of Public Preferences for Superfund Site Cleanup

## VOLUME 1:
## A Preliminary Assessment


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# Abstract

The National Priority List (NPL) was created by CERCLA to allocate the use of Superfund monies for cleanup of hazardous waste sites. Instead of providing the quick cleanup implied by the concept of a "fund," Superfund has instead resulted in lengthy delays and continuing property value losses.

In spite of the expert view that NPL sites pose little immediate threat to the public, substantial evidence from the literature suggests that many people living near such sites believe they face significant risks. These beliefs are the result of (1) EPA's assessment that these sites are of sufficient concern to be listed on the NPL, (2) the extensive and often inflammatory attention that the media gives NPL sites, and (3) the belief of a significant share of the public that experts (i.e., scientists) cannot provide accurate assessments of the health risks associated with these sites.

The seriousness with which the public views such sites is further reflected by the often large loss in nearby property values. A review of the economic literature on public preferences for cleanup of hazardous waste sites as revealed in real estate markets shows property value losses exceeding $10,000 for homes near NPL sites. The evidence also suggests that measurable property value losses can extend three or more miles from a site. Since complete site cleanup (i.e., complete removal of all contaminated substances from the site) would presumably restore property values to former levels, these property losses approximate the public's willingness to pay for complete cleanup.

Evidence from property value losses and risk beliefs indicates that the public has both a genuine fear of potential health risks from such sites and a substantial willingness to pay for site cleanup. Given that complete cleanup is extraordinarily expensive, with costs exceeding benefits in most cases, the question for policy makers becomes, What level of cleanup would be acceptable to the public?

A survey instrument was developed as part of a pilot market research study to explore preferences for alternative cleanup options. The survey describes a hypothetical NPL site with a large population in close proximity. It informs respondents of expert assessments of the magnitudes of risk and other conditions at the site. Detailed information on five cleanup options and their relative cost on a per household basis is also presented. The survey then asks respondents to select their most preferred and next preferred options. The magnitude of values for cleanup estimated in the study are consistent with estimates from property value evidence. The survey data further suggest that, given sufficient detail on actual costs and risks, the majority of individuals would select a cleanup option that was less than complete.

The implications of this research at the national level are explored by examining potential aggregate benefits and costs for cleanup of the 1,157 non-Federal NPL sites. A lower bound measure of partial cleanup benefits was estimated to be $15 billion assuming that: (1) property value effects are limited to a one-mile radius from a site, (2) household losses average $10,000, and (3) partial cleanup benefits are equal to 70% of total damages. An upper bound estimate of $89 billion was

constructed by assuming that: (1) property value effects extend to three miles around a site, (2) property value effects decline with distance from a site, and (3) partial benefits are equal to 90% of total damages. These preliminary estimates reveal that approximately 25% of the sites on the NPL generate more than 80% of the property value losses, due to the proximity of sizable populations. Furthermore, when the distribution of estimated benefits was compared to a distribution of expected cleanup costs (constructed from data in a recent CBO report (1994) on Superfund costs), the percentage of sites satisfying a benefit/cost criteria was estimated to be between 13% and 39% of all non-Federal sites currently on the NPL. In other words, cleanup beyond what is reasonable to eliminate immediate and unacceptable risks to the public is economically justified at less than half of the sites.

Several preliminary conclusions emerge from this interim study. First, NPL listing of a site appears to exacerbate the fears of nearby citizens and contribute unnecessarily to property value decline. Thus, we suggest much more stringent criteria be developed for placing sites on the NPL. For those sites where substantial property damages exist, partly due to contamination and partly due to the risk beliefs of residents living near sites, remediation efforts to levels suggested by our preliminary market research may be appropriate. Second, pilot study results suggest that many people are satisfied with options other than complete cleanup, particularly when there are risks associated with complete cleanup from the removal of hazardous substances. Third, a high priority should be placed on expedited cleanup of sites with large enough nearby populations to pass a benefit-cost test based on public preferences. The remaining sites are likely to evoke relatively little public concern. Fourth, public preferences should be incorporated into decisions regarding the extent of hazardous waste cleanup at NPL sites.

A key policy question arising from the study is how to incorporate public preferences into decisions regarding the extent of cleanup. In a democratic, free market society, public values, not the values of experts, are relevant for public decision making. The role of experts in the decision process is, instead, primarily to provide information on levels of risk and appropriate cleanup technologies. However, once information on cleanup options (including costs) is made available to citizens, the preferences of those citizens who are potentially at risk should be incorporated systematically into the decision process.

The findings and conclusions in this report are preliminary, and highlight the need for further research in a number of areas.

**VOLUME I**

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# Chapter 1

## OVERVIEW AND EXECUTIVE SUMMARY

In 1980, Congress passed the Comprehensive Environmental Recovery, Compensation, and Liability Act (CERCLA), which assigned liability for cleanup costs and created a trust fund (i.e., Superfund) to clean up abandoned hazardous waste sites. In 1986, CERCLA was reauthorized and amended with the Superfund Amendments and Reauthorization Act (SARA), which substantially increased the amount of funds available for hazardous waste cleanup. Since that time, billions of dollars have been spent on identification, classification, investigation, and remediation at hazardous waste sites around the country. Current federal expenditures alone amount to approximately $2 billion annually.

CERCLA created the National Priority List (NPL) of hazardous waste sites to allocate the use of Superfund monies to clean up these sites. The NPL was intended to contain the most dangerous sites based on the Hazard Ranking System (HRS). The HRS provides a systematic method to assess potential risks to the public and the environment from the release of hazardous substances. Over 1200 sites are currently listed on the NPL; however, fewer than 150 sites have been cleaned up. Specifically, by the end of 1992 only 148 nonfederal sites had completed construction activities and were considered completed. However, 95% of the sites have begun the Remedial Investigation/Feasibility Study (RI/FS) phase, and two-thirds of the sites are beyond the Record of Decision (ROD) phase (CBO, 1994).

Although the Superfund program was intended to provide the necessary resources to initiate site investigation and cleanup activities, legal entanglements with potentially responsible parties (PRPs) have resulted in costly and lengthy delays and in the public's growing frustration with the implementation of CERCLA. The current debate surrounding CERCLA reauthorization provides an opportunity to alter the implementation of the program to better serve the public's interest in effective and efficient cleanup of the worst hazardous waste sites.

This study, which is described in two volumes, attempts to evaluate public preferences for cleanup of hazardous waste sites. Volume I summarizes the available literature on preferences for cleanup of Superfund sites including evidence on (a) the factors contributing to public risk beliefs, and (b) how much the public values cleanup of Superfund sites. This volume also presents results from a pilot study of the assessment of community preferences, and includes an assessment of national level costs and benefits. Volume II presents the detailed technical results of the pilot study which is based on data from more than 200 individuals.

**Determinants of Risk Beliefs**

In spite of the view held by most risk assessment experts that NPL sites pose little immediate threat to public health and safety, substantial evidence was found in the literature suggesting that people living near such sites believe the risks to themselves and their families to be significant.

One of the most important determinants of risk beliefs are perceptual cues. Perceptual cues are physical aspects of a site that are perceived by local residents, and are suggestive of risk. Examples of perceptual cues include odors emanating from landfills, unusual odors or flavors in well water, unusual soil or water coloration at the site, and a heavy volume of truck traffic going in and out of the site. Proximity to a site increases the frequency and duration of contact with, or observation of, perceptual cues, which contributes directly to the intensity of risk beliefs.

Some evidence suggests that the act of listing a site on the NPL serves as a distinct cue or signal to residents of the riskiness of the site. Most residents conclude, in many cases without a clear examination of the details, that a site must indeed have serious risk levels if it warrants listing on the NPL. Both Russell (1991) and Kohlhase (1991) found that property value losses at some sites do not occur until after the sites are listed on the NPL.

Attention given to a site in the media, apart from the actual content of news stories, is itself a perceptual cue that risks may be high. Many studies have shown that frequent exposure to media reports about a site increases the likelihood that residents will believe the site is very risky. The specific risk at a site and perhaps the site itself will usually be unfamiliar to residents. That in itself increases risk beliefs (Slovic et al., 1991; Wilkins and Patterson, 1990). It also means that residents are almost totally dependent on the news media for information about the risk.

The signals that the media sends to the public regarding risks from hazardous waste sites are important, but the way in which the public interprets this information is equally important. A key feature of how news coverage is interpreted by residents is whether there is an easily identifiable "villain" responsible for the hazardous waste problems at the site.

**The Public Assessment of Expert Judgments of Risk**

The judgments of scientists and experts about the risk are only one component of the mix of news media stories and perceptual cues received by the typical citizen. Even if statements by scientists were accepted as credible, they would have to compete with the mix of the other signals and perceptual cues. As simply one component, such statements are unlikely to be the primary determinant of individual risk beliefs. Risk beliefs determined largely by media stories and other perceptual cues are unlikely to be easily changed by the pronouncements of a few scientists (Fischhoff, 1989).

Furthermore, it is unlikely that statements by scientists will be accepted as completely credible. Even when different scientists are in essential agreement, the news media often focuses on those aspects where experts disagree (Wilkins and Patterson, 1990), thus lowering the perceived credibility of the experts. The result is that the public discredits information it receives from experts because it appears that experts cannot agree among themselves and, therefore, do not really know the risk that a site presents.

Public trust in the credibility, integrity, and objectivity of experts is an important component in risk communication; there is much evidence that many people do not hold scientific assessments of risk in high regard. This lack of trust is reflected in the results from our market research pilot study. Figure 1 shows that nearly 60% of the participants either did not believe that scientists know the true health risks or believed that scientists underestimate the true risks. This implies that a major factor in public risk perception is concern for "what happens if the scientists are wrong."

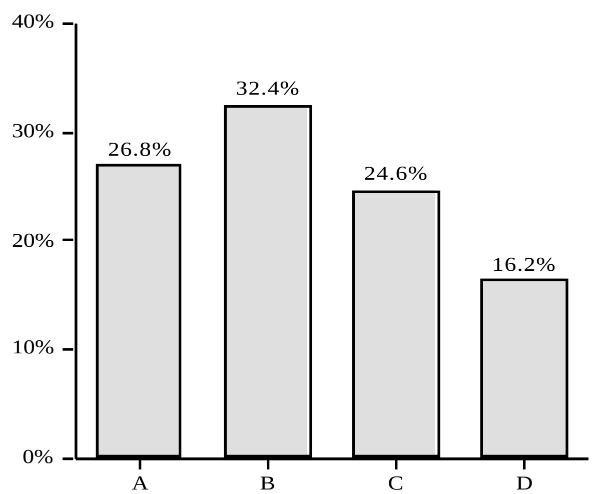
Attempts at risk communication to lower the public's risk beliefs will almost surely have limited success because (a) statements by scientists are only a small portion of the total information and perceptual cues on which citizen risk beliefs are based, and (b) statements by scientists are not likely to be perceived as credible by a significant share of the public in any case. Mitigation actions that reduce or eliminate perceptual cues are much more likely to have a favorable impact on risk beliefs. Mitigation, even if considerably short of complete cleanup, might lower risk beliefs dramatically. It is our view that even partial cleanup will have a greater favorable impact on the public's risk beliefs than efforts at risk communication from scientists and sources such as EPA.

The risk perceptions described above can motivate people to try to move away from NPL sites and may lower the demand for housing near the sites.

**FIGURE 1: SCIENTIFIC ASSESSMENTS OF HEALTH RISK (LANDFILL CHOICE SURVEYS)**

"In your opinion, when scientists estimate the human health effects of hazardous substances, they..."

**A --** Really do not know the actual health risks.
**B --** Underestimate the risks.
**C --** Are reasonably accurate in estimating the risks.
**D --** Overestimate the risks.



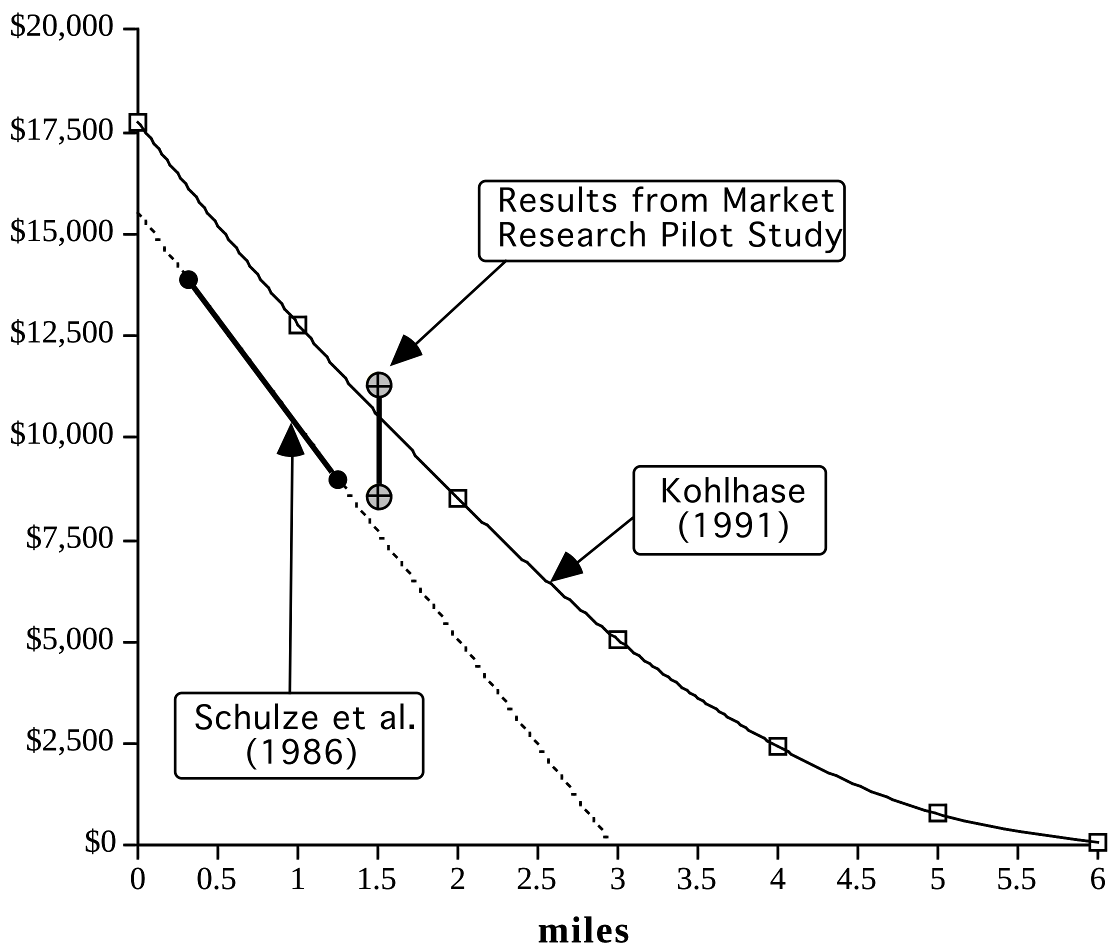

**Property Value Losses near NPL Sites**

The seriousness with which the public views such sites is further reflected in the often large loss in nearby property values. These losses reflect the shift in demand for the properties caused by the public's risk beliefs. The evidence suggests that a necessary condition for intense public concern is the close proximity of a substantial population.

An extensive review of the hedonic property value literature reveals property value losses exceeding $10,000 for homes near (1 mile or less) NPL sites. The evidence also suggests that measurable property value losses can extend three or more miles from a site. Figure 1.1 illustrates two of the estimated relationships between property value loss and distance found in the literature, and also illustrates the range of values for complete cleanup obtained from the market research pilot study described in this report.

**FIGURE 1.1**

## A Comparison Between Property Value Losses by Distance and the Market Research Results



Since complete site cleanup (i.e., complete removal of all contaminated substances from the site) would presumably restore property values to former levels, these property losses approximate the public's willingness to pay for complete cleanup. Property value losses and the evidence on risk beliefs indicate that the public has both a genuine fear of potential health risks from such sites and a substantial willingness to pay for site cleanup.

**Market Research Study of Public Preferences**

Given that complete site cleanup is extraordinarily expensive, the question for policy makers becomes, what level of cleanup would be acceptable to the public? Measures of the demand for hazardous waste site cleanup are an important component of the policy problem confronting both legislators and regulators. Unfortunately, the property value approach is unable to measure the potential benefits of partial cleanup, and presumably reflects an upper bound estimate of benefits associated with complete cleanup.

Our pilot market research study developed a methodology to address these questions. We developed a survey instrument that describes a hypothetical NPL site (a landfill and an industrial site in different versions) with a large population in close proximity. The survey informs respondents of expert assessments of the magnitudes of risk and other conditions at the site. Detailed information on five cleanup options (A. no action, B. institutional controls, C. soil cap and water filtration, D. soil cap and groundwater barrier, and E. complete cleanup) and their relative cost on a per household basis is presented. The survey then asks respondents to select their most preferred and next preferred options.

To allow statistical estimation of preferences, four versions of the survey describing a landfill NPL site were administered. Variations in the costs of cleanup were provided in different versions of the survey and, in two versions, complete cleanup was described with an associated health risk related to the removal and transportation of contaminants. Figures 3 through 6 illustrate how these different variants of the survey affected the preferred choice of respondents. In particular, observe how the choices for complete cleanup (option E) change in response to changes in complete cleanup cost and risk.

The distribution of first choice preferences for the survey version with low cost estimates for the options and no associated risk for complete cleanup is presented in Figure 3. The results indicate that nearly 50% of respondents preferred complete cleanup with the remaining preferences distributed nearly equally across options (B), (C), and (D). When a slight expert assessment of risk (1 in 10 million) is added to the consequences of complete cleanup the result is a slight shift in choices from complete cleanup toward options (C) and (D), as shown in Figure 4; however, complete cleanup is still the most preferred option. When cleanup costs are increased to levels more consistent with actual costs (i.e., $50 per household per month for ten years for complete cleanup) we begin to see the most preferred alternative shift from complete cleanup to option (D)-- landfill cap and groundwater barrier. Figure 5 illustrates the choice distribution with the combination of higher complete cleanup cost and risk, and Figure 6 illustrates the effect of higher complete cleanup cost alone. In both cases, choices shift away from complete cleanup.

The shift from complete cleanup to a partial cleanup in response to the risk associated with implementing complete cleanup is consistent with public preferences demonstrated at the Smuggler Mine near Aspen, Colorado. At this NPL site, residents supported a public referendum against complete cleanup because implementation would most likely have exposed the community to greater risks than containment (Mangone, 1993).

**FIGURE 3**
**LANDFILL CHOICE VERSION 1**
(low cost -- no risk with option E)

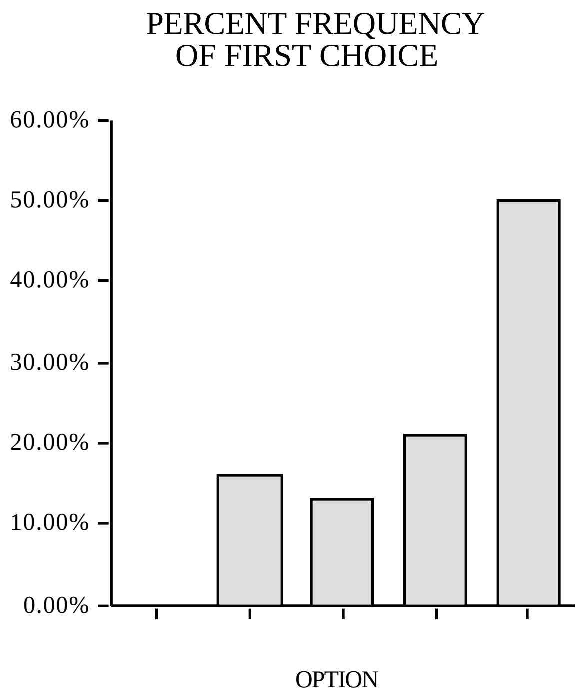



**FIGURE 4**
**LANDFILL CHOICE VERSION 2**
(low cost -- risk with option E)

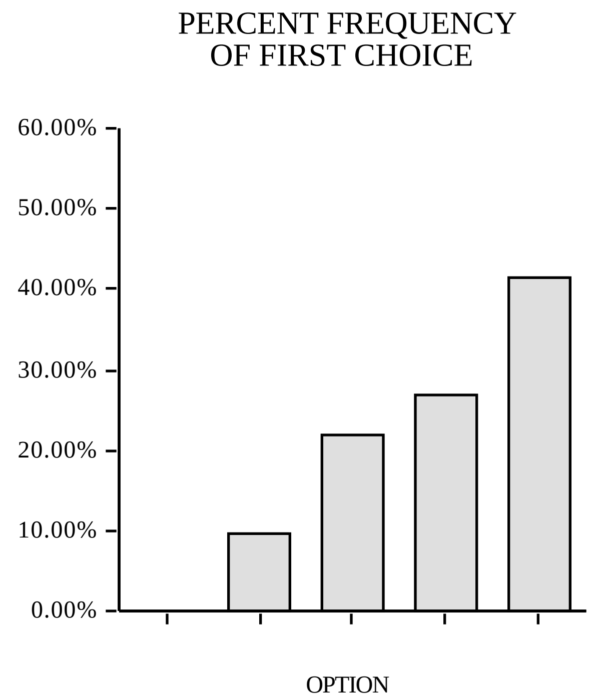



**FIGURE 5**
**LANDFILL CHOICE VERSION 3**
(high cost -- risk with option E)

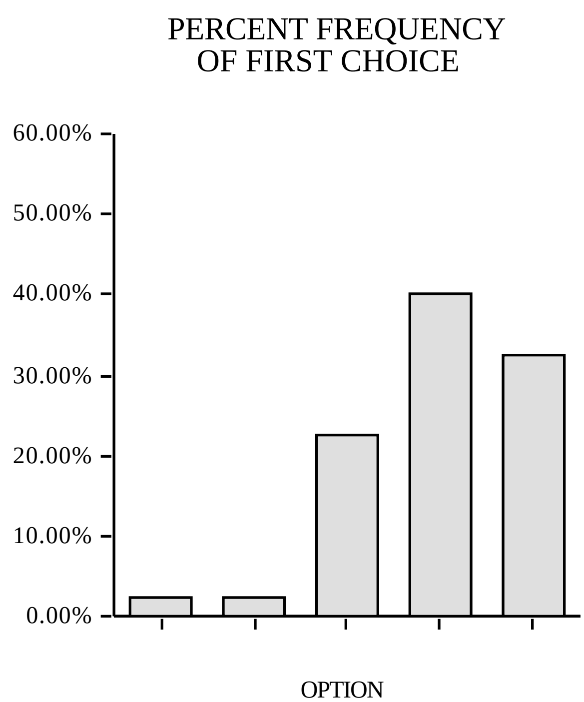



**FIGURE 6**
**LANDFILL CHOICE VERSION 4**
(high cost -- no risk with option E)

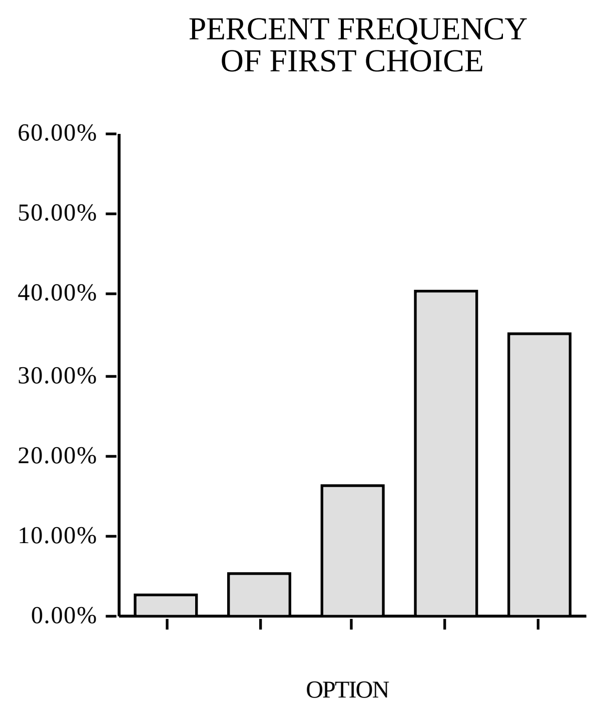
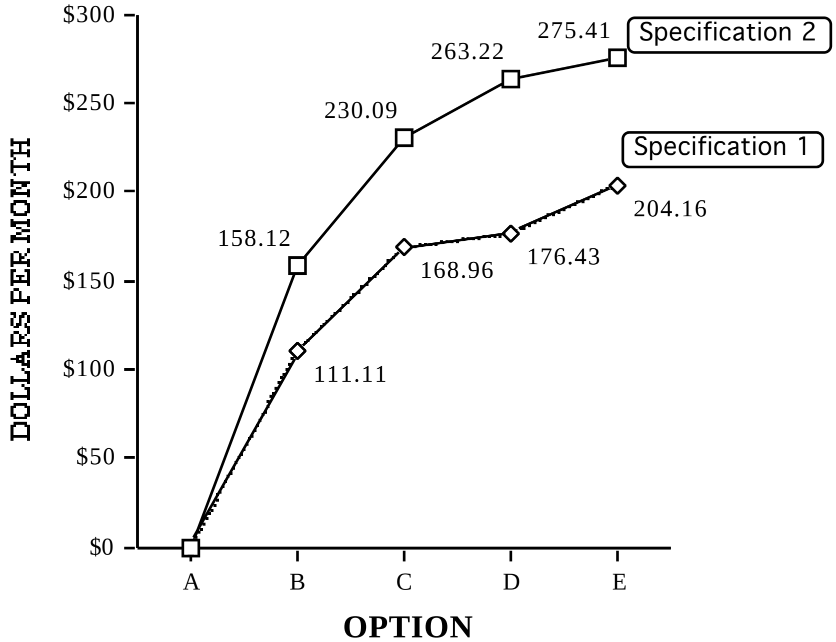


**FIGURE 1.4**
**WILLINGNESS TO PAY FOR CLEANUP OPTIONS**
**(LANDFILL CHOICE SURVEYS)**




**Options**
A -- No Action
B -- Institutional Controls
C -- Soil Cap and Water Filtration
D -- Soil Cap and Groundwater Barrier
E -- Complete Cleanup

Survey responses were used to estimate preferences using market analysis and derive willingness to pay for each option. Figure 1.4 summarizes respondents' willingness to pay for cleanup options. Survey respondents indicated through their choices that they would be willing to pay between 70% and 90% of what they would pay for complete cleanup for site capping and a groundwater barrier (option D).[1] In other words, the capping option is both acceptable and passes the individual benefit-cost test in situations where a substantial population lives near the site (if nearby households each had to pay their share of the cost of cleanup, they would mostly

[1] The basis for this percentage comparison is option B, institutional controls. Respondents were told that institutional controls are in place -- which is true at most NPL sites.

choose option D). The values for complete cleanup implied by respondents' choices are consistent with the losses found in property value studies (Figure 1.1).[2]

**National Implications and Economic Benefits**

The implications of this research at the national level are explored by examining potential aggregate benefits and costs for cleanup of non-Federal NPL sites. Using the NPL Characterization Project Database (ICF, 1992), we estimate a lower bound measure of partial cleanup benefits for the 1,157 non-Federal NPL sites to be $15 billion assuming that: (1) property value effects are limited to a one-mile radius from a site, (2) household losses average $10,000, and (3) partial cleanup benefits are equal to 70% of total damages. An upper bound estimate of $89 billion is constructed by assuming that: (1) property value effects extend to three miles around a site, (2) property value effects decline with distance from a site, and (3) partial benefits are equal to 90% of total damages. Considerable uncertainty surrounds the issue of market size and, as the numbers above suggest, resolution of this issue will be critical to an accurate estimation of the benefits of cleanup. A frequency distribution of potential benefits showed that approximately 25% of sites generate more than 80% of the property value losses due to their proximity to sizable populations.

To compare these estimated benefits with the expected costs of cleanup we relied on data from a recent report on Superfund costs (CBO, 1994). The report categorizes three types of sites based on their expected cleanup cost and estimates the proportion of sites at each level. This information was used to approximate a distribution of costs which was then compared with the distribution of estimated benefits. Assuming independence between the distribution of costs and the

2 The results shown for the market research study are the capitalized values for complete cleanup rather than institutional controls from the two specifications shown in Figure 1.4.

distribution of benefits, we estimate that the likelihood that benefits exceed costs at a given site lies between 13% and 39%. In other words, cleanup beyond what is reasonable to eliminate immediate and unacceptable risks to the public is economically justified at less than half of the sites.

**Preliminary Conclusions**

Several preliminary conclusions emerge from this interim study: (1) NPL listing of a site appears to exacerbate the fears of nearby citizens. Instead of providing the quick cleanup implied by the concept of a "fund," Superfund has instead resulted in lengthy delays and continuing property value losses. By placing a site on the NPL, the EPA is, in effect, telling nearby citizens that they are in danger. Although listing new sites (unless a serious immediate risk is present) would send the wrong signal, delisting sites already on the NPL would very likely leave nearby residents feeling outraged and abandoned. Just as risk communication has failed to convince the public that off-site risks are negligible, delisting sites will most likely be viewed as an attempt to sweep the problem under the rug. Thus, we suggest that much more stringent criteria be developed for placing sites on the NPL. (2) Our pilot study results suggest that many people are satisfied with options other than complete cleanup, particularly when there are risks associated with complete cleanup from the removal of hazardous substances. (3) The magnitude of the value estimates for complete cleanup obtained from the pilot study are consistent with estimates from property value studies. (4) Preliminary analysis estimating the national economic benefits of partial cleanup at NPL sites found that approximately 25% of the sites on the NPL are associated with over 80% of the property value losses. Furthermore, the percentage of sites satisfying a benefit/cost criteria was estimated between 13% and 39% of all non-Federal sites currently on the NPL. This evidence suggests that greater flexibility should be incorporated into the selection of remedial action alternatives at NPL sites, especially when future land-uses of sites and the size of nearby populations are considered (see Viscusi and Hamilton, 1994). Note that our estimates of damages and benefits for the most part exclude natural resource injury (i.e., we have excluded recreation losses, non-use values, etc. from the analysis).

**Public Preferences and Policy**

The primary policy question that arises from the study is how to incorporate public preferences into decisions regarding the extent of cleanup. In a democratic, free market society, public values, not the values of experts, are relevant for public decision making. Expert information on levels of risk and appropriate cleanup technologies are relevant to the decision process. Unless the public is fully informed of alternative options, it is likely to demand complete cleanup of sites and be unaware of acceptable lower cost alternatives, adoption of which would speed cleanup. However, once information on cleanup options is made available to citizens, the preferences of those citizens who are potentially at risk should be incorporated into the decision process. A decision making process that involves the public explicitly could both speed cleanup and result in the selection of less costly remedies that satisfy the public. Current USEPA practice at least partly conforms to this process (see Chapter 2). However, such procedures are not now, but perhaps should be, formally incorporated into law.

**Future Research**

These conclusions are very preliminary and motivate substantial research needs. First, a better understanding is required of the formation of risk beliefs at NPL sites. Second, the issue of market size has a critical impact on the appropriate level and extent of site cleanup. Thus, to better assess the likely scope of Superfund cleanup, detailed, site-specific market research is required since existing property value studies may not accurately measure the extent of the market.[3] Third, additional research on public preferences should be done to explore the role of providing information on cleanup options, including issues such as future land-uses.

Volume I of this report is organized as follows: Chapter 2 compares situations at two different NPL hazardous waste sites, demonstrating the desirable flexibility in cleanup options. Chapter 3 discusses how public risk beliefs are formed and why risk communication efforts may fail. Chapter 4 consists of a review of the economic literature on public preferences for cleanup of hazardous waste sites as revealed in real estate markets. Chapter 5 describes the results from the pilot market research study where preferences for alternative cleanup options are explored. Chapter 6, a national assessment of the magnitude of economic benefits associated with NPL site cleanup is made. A model for extent of market is developed. Then upper and lower bound estimates of the total property value losses and benefits associated with partial cleanup of NPL sites are constructed. These estimates are used to construct frequency distributions of potential benefits of partial cleanup. Chapter 7 provides conclusions and policy suggestions based on our preliminary assessment.

[3] Because NPL sites tend to be located in industrial areas that contain many undesirable facilities which are viewed as disamenities by nearby residents, existing property value studies may overestimate the extent of the market. The extent of the market can be determined only by directly measuring the risk beliefs of nearby residents. Similarly, to the extent that non-use values are present, property value studies may underestimate the extent of the market.

# Chapter 2

# A LITTLE OR A LOT? THE RANGE OF CLEANUP ACTIONS

There has been great diversity in the cleanup and remedial actions taken at NPL sites across the country. In some cases the Record of Decision (ROD), which details the actions to be taken at an NPL site, prescribes little more than active monitoring of the site; at other sites the RODs prescribe extensive remediation. In this chapter we describe as examples the contrasting actions taken at two NPL landfill sites. Our goal is to demonstrate the range of actions that have been acceptable to the public in different situations.

## 2.1 Suffolk City Landfill, Suffolk, Virginia

The Suffolk City Landfill is located in southeastern Virginia outside of the city of Suffolk which has a population of 51,200. It is estimated that 129 people live within one mile of the site (ICF, 1992) and 2,500 people use well water drawn within three miles of the site (Jennifer Ebert, USEPA, personal communication). The landfill covers 67 acres and is owned by the city of Suffolk. The landfill was used for municipal refuse disposal from 1967 to 1985 and was also used for the disposal of 27 tons of agricultural chemicals that were damaged in a fire in 1970. When the landfill was closed in 1985, the city was concerned about the prior disposal of the chemicals and evaluated the potential threats associated with the chemicals in the landfill. After evaluation using the Hazard Ranking System (HRS), the site was proposed for and finally included on the NPL in February 1990. Upon completion of the Remedial Investigation/Feasibility Study (RI/FS), it was determined that the site did not warrant further cleanup and the final remedy of "no action, with groundwater monitoring" was recommended and accepted as part of the ROD signed in September 1992. The basis for this decision followed from the findings that (a) there was no off-site migration of groundwater, (b) surface waters were safe for aquatic life, (c) no unacceptable risks to human health were expected from the site, and (d) monitoring would alert any changes in site conditions.

Cantor (1993), in a study of community preferences at the Suffolk City Landfill, surveyed city officials and residents concerning their perceptions and preferences for cleanup of the site. Both groups found removal and disposal of the contaminants acceptable, while incineration of the contaminants and relocation of affected residents were unacceptable. The only difference between the preferences of the two groups was that city officials thought it best to contain and monitor the site, while this was not the most preferred action of residents. Residents preferred to extend city water lines to well owners in the area (an action that was acceptable but not preferred by city officials). The ROD prescribed "no action" be taken except for continued monitoring of the groundwater below the site. The "no action" alternative has proven to be acceptable to the community in spite of a preference by citizens for extending city water lines.

## 2.2 Operating Industries, Inc. Landfill, Monterey Park, California

The privately owned Operating Industries, Inc. (OII) Landfill covers 190 acres and is located 10 miles east of Los Angeles in the suburb of Monterey Park. More than 20,000 people are estimated to live within one mile of the site (ICF, 1992), in an area that is middle income and multi-racial. The OII Landfill has been the subject of intense regional attention since the early 1980s when hazardous waste and landfill gas problems began to arise.

The OII Landfill began operations in 1948, a time when there was little neighboring development. During its history the landfill accepted a variety of municipal and industrial wastes, including various hazardous wastes. As the population in southern California grew, development pressure was felt throughout the municipalities near Los Angeles. In the mid 1970s, the land surrounding the OII landfill was approved for residential development, and soon a middle income neighborhood encircled the OII landfill. Rapid development was motivated, in part, by promised closure and development of a golf course on the site. In 1979, residents near the landfill formed a group aimed at addressing what they felt were increasing problems at the landfill. Homeowners to Eliminate Landfill Problems (HELP) organized to reduce odor and to eliminate suspected health problems associated with the site. The organization addressed specific issues such as leachate seepage, methane buildup, land use after closure of the site, and declining property values.

In 1984 the landfill reached its capacity and was closed. However, before its closure several incidents at the landfill drew attention to potential problems. As a result of the buildup of methane within the landfill, several underground fires occurred in June 1983, and potentially explosive levels of methane were detected underneath several streets adjacent to the landfill. Also in 1983, vinyl chloride was detected in the air around the landfill in excess of EPA and state standards. This series of events led the state to include the site on the California Hazardous Waste Priority List in January 1984, which was soon followed by EPA action to include the landfill on the NPL.

Since its inclusion on the NPL, both the EPA and the State of California have been active in the assessment and design of remedial activities. An RI/FS, begun in 1986, recommended long-term studies of the OII site to assess the extent and nature of the problems and to provide guidance on the design of remedial measures. The California Department of Health Services also conducted an extensive epidemiological investigation comparing health symptoms of residents near the site with those of control communities (Satin et al., 1986). The results indicated no significant differences between the incidence of health symptoms of residents and those in the control communities.

Since 1989, a series of three settlements have been agreed to by EPA, the state, and the PRPs to remediate problems at the OII landfill. The cost of these settlements amounts to over $205 million, not including anticipated settlements regarding groundwater treatment (if necessary) and final remedy at the site.

## 2.3 Conclusions

There are several differences between these two sites that may contribute to the divergence in the selected remedies. Among these differences are the size of nearby populations, the presence of an explosion risk at one site, and the identification of a known carcinogen (vinyl chloride). One of the most important differences is the subjective risk beliefs of residents living near the sites. The naming of a site to the NPL begins a process through which public perceptions of the risks associated with the site are formed. Often, the process results in a large disparity between the public's beliefs about the risk and the beliefs of experts. While experts often dismiss the risks at hazardous waste sites as minimal, residents living near these sites tend to believe that they face considerable risk and that the experts are wrong in their assessments. What, then, is the appropriate level of cleanup for these NPL sites given the often rising and significant costs associated with greater levels of cleanup? What determines the public's risk beliefs and how should these beliefs be incorporated into policy decision making?

The next chapter focuses on the process by which individuals form risk beliefs and how efforts at risk communication may fail.

# Chapter 3

# DETERMINANTS OF RISK BELIEFS

Individual risk beliefs associated with hazardous waste sites have many determinants in addition to information from scientific assessments. The two case studies introduced in the previous chapter are useful for illustrating these determinants. Furthermore, differences in the determinants at the two sites may explain why risk beliefs were very high at the OII site, but relatively low at the Suffolk City site.

## 3.1 The Role of Perceptual Cues

One of the most important determinants of risk beliefs are perceptual cues. Perceptual cues are physical aspects of a site that are perceived by local residents, and are suggestive of risk. Examples of perceptual cues include odors emanating from landfills, unusual odors or flavors in well water, unusual soil or water coloration at the site, and a heavy volume of truck traffic going in and out of the site. Ironically, some of the actions taken by authorities to minimize public health and safety risks tend to exacerbate risk beliefs by providing clear cues that some risk is present. Erecting chain link fences, placing warning signs, conducting on-site tests (especially by workers wearing protective clothing) are all cues to residents that risk levels may be higher than they thought. Such actions, which may be necessary, almost never lower risk beliefs. Proximity to a site increases the frequency and duration of contact with, or observation of, perceptual cues, which contributes directly to the intensity of risk beliefs.

In contrast, hazards without strong perceptual cues or dreaded consequences often generate risk beliefs that are lower than expert assessments (Doyle et al., 1989). For example, the public tends to underestimate the risks of radon gas in homes; being odorless, colorless, and tasteless, radon gas has essentially no perceptual cues. As Doyle and colleagues demonstrate, public concern for risks without strong perceptual cues, such as radon, is weak and not strongly influenced by risk communication efforts directed towards increasing public concern.

The effects of strong perceptual cues are well illustrated by the OII Landfill. Initially, concern about high volumes of truck traffic and odors (produced by decomposition in the landfill) prompted local residents to organize and confront problems associated with the site. McClelland et al. (1990) found a significant correlation between recognition of these perceptual cues and the high risk beliefs of many residents living near the site. Several of the perceptual cues were removed or reduced by (a) installing wells to extract the methane gas for commercial use and (b) closing the site, which eliminated most of the truck traffic. Even though these actions did not address risks that hazardous substances would migrate into local neighborhoods, the risk estimates of many residents dropped dramatically after the principal perceptual cues were removed. McClelland et al. also demonstrated that there were significant property value losses associated with these risk beliefs. Closing the site reduced the magnitude of these losses.

In contrast, at Suffolk City Landfill there were fewer perceptual cues and, most importantly, there were fewer people to perceive them. While there were over 20,000 people living within one mile of the OII Landfill, only 129 people were estimated to live within one mile of the Suffolk City Landfill. The paucity of perceptual cues and the lack of people to perceive them may explain why the citizen reaction to the Suffolk City Landfill was much calmer than the reaction to the OII Landfill.

### 3.2 Listing on the NPL

Some evidence suggests that the act of listing a site on the NPL serves as a distinct cue or signal to residents of the riskiness of the site. Most residents conclude, in many cases without a clear examination of the details, that a site must indeed have serious risk levels if it warrants listing on the NPL. Both Russell et al. (1991) and Kohlhase (1991) found that property value losses at some sites do not occur until after the sites are listed on the NPL. Both OII and Suffolk City were listed on the NPL, yet apparently very different risk beliefs were created in the two communities. Hence, the more important factor may be how the NPL listing is treated by the news media.

### 3.3 Cues from the News Media and Their Interpretation

Attention given to a site in the media, apart from the actual content of news stories, is itself a perceptual cue that risks may be high. Many studies have shown that frequent exposure to media reports about a site increases the likelihood that residents will believe the site is very risky. The specific risk at a site and perhaps the site itself will usually be unfamiliar to residents. That in itself increases risk beliefs (Slovic et al., 1991; Wilkins and Patterson, 1990). But more importantly, it means that residents are almost totally dependent on the news media for information about the risk. Reflecting the concerns of their consumers, the news media often focus on aspects that accentuate dread, such as the uncontrollability of the risk and the frightful worst outcome (e.g., dying of cancer) rather than on information about the low probabilities of the risk and how those probabilities compare to other risks that residents accept.

The signals that the media sends to the public regarding risks from hazardous waste sites are important, but the way in which the public interprets this information is equally important. A key feature of how news coverage is interpreted by residents is whether there is an easily identifiable "villain" responsible for the hazardous waste problems at the site. For example, if the responsible party is a corporation whose primary business activity is outside the community, then it is more easily portrayed as a villain than a local business which has strong affiliations to the community. Russell et al. (1991) found that the more important a site's PRPs (potentially responsible party) were to the local economy, the more skeptical residents living near the site were that it needed to be cleaned up. Personal familiarity with a site also influences how news reports are interpreted. The greater the prior familiarity, the less risk beliefs are likely to be elevated by news stories.

The PRP for the OII Landfill was an outside corporation that had not provided significant employment or other economic benefits for the residents who lived nearby. Most of the waste, especially that which was hazardous, was generated and brought to OII from outside the community. OII was primarily a commercial landfill serving many interests outside of the community. In short, conditions were ripe for news stories to elevate risk concerns significantly. At Suffolk City, on the other hand, the city and by extension its taxpayers were the PRPs. The landfill had been the city dump, so everyone in the community had benefited and many had personal experience with the site from taking a load or two to the town dump. The potentially hazardous wastes at the site came from agricultural chemicals which, too, had benefited the local economy. In short, conditions were such that news stories were unlikely to create an image of a dreaded risk imposed by an outside villain.

How a risk affects the community, society, and the economy will depend on individual and group perceptions of the risk (Slovic et al., 1991). How a risk is interpreted by the public can lead to the risk having greater consequences on society than the direct impact of the risk. Consider, for example, the recent Tylenol scare incident in which several bottles were intentionally contaminated with poison. Despite the fact that the probability of being poisoned from taking Tylenol was minuscule, the company lost millions of dollars in sales because of public fears and the ready availability of substitute brands. The substitutes, of course, were not immune from tampering; hence the observed switching behavior was not justified as a response to risk alone. The ultimate effect was a considerable increase in production costs to prevent a very low probability risk by ensuring that all packaging of over-the-counter medicines is tamper-proof. However, the more recent faked tampering with Pepsi products shows that sometimes the correct risk level can be communicated.

The tampering examples demonstrate that there can be a compounding or "rippling" effect as more and more individuals respond to the risk (Kasperson et al., 1988). Or, as Dr. Paul Slovic describes it, interactions among individuals can produce a "social amplification of the original risk concern." The greater the population living near a site, the greater the potential for compounding or social amplification.

### 3.4 The Public Assessment of Expert Judgments of Risk

The judgments of scientists and experts about the risk are only one component of the mix of news media stories and perceptual cues received by the typical citizen. Even if statements by scientists were accepted as credible, they would have to compete with the mix of the other signals and perceptual cues. As simply one component, such statements are unlikely to be the primary determinant of individual risk beliefs. Risk beliefs determined largely by media stories and other perceptual cues are unlikely to be easily changed by the pronouncements of a few scientists (Fischhoff, 1989).

Furthermore, it is unlikely that statements by scientists will be accepted as completely credible. Even when different scientists are in essential agreement, the news media often focuses on those aspects where experts disagree (Wilkins and Patterson, 1990), thus lowering the perceived credibility of the experts. In a study examining news coverage of Three Mile Island and Chernobyl, Rubin (1987) found that news stories tended to dichotomize events rather than blend a continuum of information to recipients. The result is that the public discredits information it receives from experts because it appears that experts cannot agree among themselves and, therefore, do not really know the risk that a site presents.

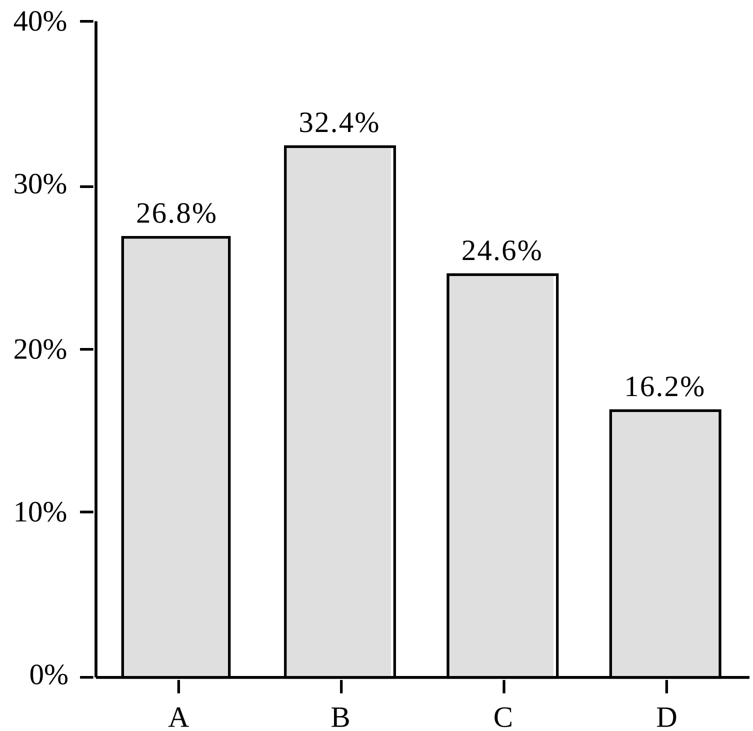
Public trust in the credibility, integrity, and objectivity of experts is an important component in risk communication; there is much evidence that many people do not hold scientific assessments of risk in high regard.

This lack of trust in the expert assessment of risk is reflected in the results from our market research pilot study. Figure 3.1 shows that nearly 60% of the participants either did not believe that scientists know the true health risks or believed that scientists underestimate the true risks. This implies that a major factor in public risk perception is concern for "what happens if the scientists are wrong." To illustrate the critical role that this question plays in subjective risk beliefs it is useful to note the reaction of one of our pilot market research respondents who relied on the expert assessment of risk presented in the survey (as part of pretesting we taped the comments of a number of the respondents while taking the survey).

> "If I had not been aware (of the scientific estimate) of the risk, I would have assumed that it was one in a hundred, you know." **Protocol 3, Vol 2, Appendix D.**

**FIGURE 3.1**

**SCIENTIFIC ASSESSMENTS OF HEALTH RISK
(LANDFILL CHOICE SURVEYS)**




"In your opinion, when scientists estimate the human health effects of hazardous substances, they..."

- **A --** Really do not know the actual health risks.
- **B --** Underestimate the risks.
- **C --** Are reasonably accurate in estimating the risks.
- **D --** Overestimate the risks.

However, before choosing a relatively expensive cleanup option rather than a lesser option such as "no action" (option C), this same respondent also stated,

> "I would not be satisfied with leaving the waste in the storage tank left to contaminate the water again...Even though the risk, 10 deaths in 10 million people,... I just don't like the idea of it being left there."

Obviously, this respondent had some remaining doubt concerning the safety of the site. The perceptual cue of the remaining tank of hazardous waste (if institutional controls were chosen) overpowered the scientific estimate of risk and led her to avoid less costly institutional controls. If this individual thought that the odds that scientists were wrong was one in ten, then, given her assessment of the risk if scientists are wrong is 1 death in one hundred, the subjective probability would be:

$$.9 \times 10 \text{ deaths} / 10 \text{ million people} + .1 \times 1 \text{ death} / 100 \text{ people} \approx 10^{-3}.$$

In other words, the final subjective probability is determined in great part by the subjective credibility of scientific estimates of risk.

Unfortunately, as discussed above, the general public often doubts the credibility of scientists. For example, another respondent in our verbal protocol sessions reacted to the risk information by stating:

> "I think it depends a lot upon who is paying the scientists and where they're coming from and what kind of answers are wanted. I think risks are always underestimated simply because we don't know where things can lead." **Protocol 20, Q10, Vol. 2 Appendix D**.

These responses show how critical the credibility of expert opinion is in affecting individual risk beliefs. The simple model of risk belief which includes expert credibility also suggests that the magnitude of property value losses (discussed in the following chapter) is consistent and plausible in spite of expert risk assessments which suggest minimal impacts.

### 3.5 Conclusions

Attempts at risk communication to lower the public's risk beliefs will almost surely have limited success because (a) statements by scientists are only a small portion of the total information and perceptual cues on which citizen risk beliefs are based, and (b) statements by scientists are not likely to be perceived as credible by a significant share of the public in any case. Mitigation actions that reduce or eliminate perceptual cues are much more likely to have a favorable impact on risk beliefs. Mitigation, even if considerably short of complete cleanup, might lower risk beliefs dramatically. Even partial cleanup will have a greater favorable impact on the public's risk beliefs than efforts at risk communication from scientists and sources such as EPA.

These perceptions affect people and their demand for housing. The next chapter provides a summary of the evidence on property losses associated with proximity to NPL sites.

# Chapter 4

# EVIDENCE FROM THE LITERATURE ON PROPERTY VALUE LOSSES FROM HAZARDOUS WASTE SITES

Measures of the demand for hazardous waste site cleanup are an important component of the policy problem confronting both legislators and regulators. Beset with the problem of allocating state and federal resources toward the cleanup of these sites, public officials have the responsibility to ensure that these monies are used in a beneficial and cost effective manner. Are the costs of cleanup commensurate with the benefits accruing to the community? Unfortunately, these officials often make decisions concerning the priorities and extent of cleanups without any insight into the magnitude and distribution of the resulting benefits. In this Chapter we assemble the available evidence from the hedonic property value literature on the economic benefits associated with hazardous waste site cleanup. This evidence is then used later in the report to (1) establish a benchmark for comparing the results from our pilot study, and (2) guide in the development of aggregate benefit estimates which are based on the proximity of homes to NPL sites.

## 4.1 Measuring Values with Hedonic Prices

The hedonic valuation method is a technique for estimating the implicit prices of characteristics which differentiate closely related goods (Rosen, 1974; Freeman, 1979). For example, when applied to real estate markets, the hedonic property value method decomposes the total price paid for the property into implicit prices for various attributes of the property. The estimated coefficients in a hedonic price function reflect the marginal contribution of specific characteristics to the value of the property. In this method, statistical techniques are used to account for the price effects of a nearby hazardous waste site as well as other factors that affect prices, including home attributes (e.g., square feet, swimming pool), local amenities (e.g., proximity to parks or schools), and disamenities (e.g., freeway or airport noise, other industrial sites, and air pollution).

If a community is located near more than one significant disamenity, there are added difficulties in accounting for the simultaneous effects. For example, a prominent NPL site in the Denver area is the Rocky Mountain Arsenal (RMA) which is adjacent to Stapleton Airport. Measures of nuisance for both sites should be included in constructing a model of property values for the area. However, such data are not readily available.

In our current setting, we are interested in the effect that a hazardous waste site has on nearby property values. By observing how property values vary with proximity to a site, we can estimate the implied market value for distance from a site. This relationship between distance and price is typically the result of the transactions of a number of buyers and sellers with differing tastes (e.g., for risk) and incomes. Although this gradient does not, in general, represent the demand schedule for the characteristic, it can be useful in bounding the benefits associated with non-marginal changes in the characteristic (Bartik, 1988; Brookshire et al., 1982).

As discussed in the previous Chapter, perceived risk / nuisance by the community of property buyers and sellers is the key factor affecting the underlying demand for homes near a hazardous waste facility. These perceptions affect people and their demand for housing. Other items being equal, an individual will hold a lower willingness to pay for a home where there may be some health risk. Even if this risk belief is held by only some of the residents and potential buyers, the effects on the market can be measurable if the presence of the site is sufficient to impede home sales. In this case, households who would otherwise like to move, due principally to the high psychological costs of remaining, face a market in which there are few potential buyers.[4] In cases where the loss in property value due to the presence of a hazardous facility persists over time, the lower prices reflect a change in market fundamentals (e.g., a shift in demand), not simply a pecuniary transfer among individuals with different tastes. The presence of moving and other transaction costs associated with home buying and selling further reduce the potential for market activity, particularly when these transaction costs are similar in magnitude to the loss in property value. This point is further clarified in the following simulation experiment of a simple real estate market.

### 4.1.1 A Simple Market Simulation Example

A simple model of a property market was constructed to simulate the effects of risk beliefs and transaction costs on market equilibrium prices of homes in proximity to a hazardous facility. In this model we assumed there were 10 homes and 100 potential home owners (including the 10 current owners). Ownership in the model is represented by the individuals with the 10 highest bids, net any transaction / moving costs. A randomly selected bid was assigned to each of the 100 individuals. This bid was drawn from a normal distribution of bids with a mean of $130,000 and a standard deviation of $26,000. We assumed that the market was comprised of an equal share of two types of individuals: those with risk beliefs and those without risk beliefs associated with a nearby hazardous facility. The implicit cost of holding risk beliefs was assumed to be constant and equal to $10,000.

In the simulation, we assumed that an equilibrium existed prior to the awareness of the site, and was reflected by the home ownership of the ten highest

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[4] Galster (1986) argues that a necessary and sufficient condition for lower property prices in the long run is that "the number of dwellings within the zone of externalities is greater than the number of indifferent households who could occupy them (via moving both from within and from outside the given city."

bids. After individuals became aware of the potential risks from the site, a random selection of 50 bids were each lowered by $10,000. The resulting ex post equilibrium still consisted of the 10 highest bids; however, the ranking of the ex post bids reflected the loss in value from 50% of the potential buyers and the ordinal shifts in the ranking of bids, some of which represent "new" owners. The difference in the values for the top ten bids were averaged and the number of "moves" were counted (e.g., the number of individuals moving into (or out of) the set of 10 top bids).

The following results emerged from a sample of 30 simulation runs. Without imposing transaction / moving costs on potential trades, the average per house loss in value was $4,290 with a standard deviation of $1,609. The number of individuals moving averaged 1.87 with a standard deviation of 1.01.

In contrast, when we introduced a transaction cost equal to $8,000 per move (reflecting the transaction costs of both buyer and seller), the average loss per home rose to $5,267 and the average number of moves fell to 0.33. Thus, the imposition of a reasonable level of transaction costs appears to nearly eliminate market adjustments (i.e., moves) and to substantially reduce the potential of arbitrage (i.e., trading) to diminish welfare losses. The results suggested that without adjustment (i.e., an active real estate market) the welfare loss is equal to the sum of losses over the number of individuals in the community with risk beliefs.

This model suggests that as long as transaction costs are similar in magnitude to the costs of holding risk beliefs, then few moves are likely to be made (i.e., the market will shut down). This result is amplified as the number of homes away from the site becomes large. In this case, potential buyers have no incentives to research their risk beliefs and will find satisfaction in the ready availability of substitutes.

## 4.2 Hedonic Property Values and Hazardous Waste Sites: Some Results

The key to an effective study of hedonic property values is the identification of a variable which correlates strongly with perceptions of the site and which varies significantly across properties affected by the site. Typically, this variable is some measure of proximity to the site such as distance (e.g., see McClelland et al., 1990; Kohlhase, 1991; Michaels et al., 1992) or a zonal region (e.g., see Mendelsohn et al., 1992). In some property value studies of hazardous waste sites, macro level data were used rather than individual property data. These studies typically used the number of hazardous waste sites in a region as a factor to explain averages in regional housing prices (e.g., Ketkar, 1992; Walker and Hoehn, 1993). Because of the aggregate nature of these studies, it is more difficult to accurately measure the disamenity value associated with hazardous waste sites since, as we argue below, the impacts on property values are likely to be quite localized relative to the limited spatial resolution of regional level models.

In one of the earliest property value studies measuring damages associated with a hazardous waste site, Harrison and Stock (1984) used data from the Boston area to estimate a housing price function that included a measure of proximity to 11 hazardous waste sites in the area. Their analysis included 2,182 housing transactions between November 1977 and March 1981. In their model, they counted the number of hazardous waste sites within half-mile rings around each house. In this specification, the number of sites did not perform as expected and was not statistically significant; however, their results did reveal a strong effect for homes nearest to sites out to approximately one mile. Beyond one mile, they speculated that unaccounted amenity and disamenity effects from other sources (i.e., shopping areas and other industry) made it difficult to detect a strong signal from the nearest hazardous waste site. Their estimates suggested that the WTP of households with homes which were priced higher than $100,000, and which were located approximately one and a half-miles from the site, was $1,600 in 1980 dollars; whereas if the home was a half mile from the site the WTP increased to $13,500 in 1980 dollars. Adjusting these values for inflation leads to current (1993 dollar) estimates of $2,810 and $23,715, respectively.

Using these data, Michaels and Smith (1990) further explored the effects of housing market definition in property value studies. They combined the data with information from real estate agents who identified four significant submarkets in an effort to increase the explanatory power of their model. The results were mixed when analyzing submarkets individually; however, the results improved when the samples were pooled, although the distance variable remained statistically insignificant. In interpreting these difficulties, Michaels and Smith state that "any distance/timing measure is, at best, a poor proxy for households' perceptions of the disamenity and risk associated with hazardous wastes sites." This observation underscores one of the essential issues in property value studies -- a clear and pronounced perception of the problem by a wide cross section of the population. Without this pronounced perception, the real estate market will not reflect the disamenity and risk values associated with hazardous waste sites.

**THIS NEXT PARAGRAPH IS A MESS**

Schulze et al. (1986) examined the effect of distance in explaining property values near three landfills. Their analysis of 185 home sales near the BKK Landfill in West Covina, California, revealed a possible effect over time associated with the evacuation of 19 families near the site in July 1984 because of excessive levels of methane. Their results suggested that the value of homes nearest the landfill were $8,800 lower (approximately $11,840 in current dollars) relative to comparable homes further from the site. Analysis of the evacuation effect suggested that this was a significant event influencing risk beliefs-- thus affecting the local real estate market. The pre-evacuation loss was estimated at $5,700. After the evacuation, the estimation showed an additional loss of $12,000 (i.e., a total of $17,700 in 1985 dollars).

In a second study, Schulze et al. (1986) estimate a hedonic price function for homes near the Operating Industries, Inc. (OII) landfill in Monterey Park, California. Results from their analysis revealed that distance was a significant factor explaining home price variation. Both cases (BKK and OII landfills) involved established middle class neighborhoods near the site. The presence of such sizable populations near the sites probably contributed to heightened risk perceptions by the public.

In contrast, the third site studied by Schulze et al. was on the edge of a large urban area. However, few homes were located next to the site, and most of the homes in the analysis were more than two miles from the site. In this case, the statistical analysis did not support the hypothesis that property values were affected by the site at that distance. This evidence supports the view that strong perceptual cues and nearby populations are necessary for the social amplification of risk perceptions that lead to declining property values.

The negative impacts of hazardous waste sites are not limited to property value losses but may also include losses in recreation value and non-use values. An example of these impacts is described by Rowe et al. (1985), who performed a natural resource damage assessment (NRDA) of the economic damages associated with the Eagle Mine. Contamination from this site polluted a stretch of the Eagle River near Vail, Colorado affecting both residents and recreation enthusiasts. Property value damages were estimated at $24,000 per household for residents living along the visibly contaminated Eagle River. Remedial actions taken by potentially responsible parties to remove contaminant sources at the site have contributed, in part, to a significant recovery of property values in the area, which is receiving increasing recreational pressure from both summer and winter users.

The importance of community variables is often reflected by the low explanatory power of many property value studies lacking this control. Inclusion of community and neighborhood variables often reduces the noise inherent in the data and improves the likelihood of detecting the effect of a hazardous waste facility. The overall explanatory power of each of three models estimated by Michaels et al. (1992) was quite low (i.e., $R^2$ of 0.26, 0.25, and 0.14, respectively), even though distance was usually significant. Their data, obtained from government and tax assessor records, provided limited information on structural characteristics for homes sold within 10 miles of the sites; however, community or neighborhood characteristics were not included because of budget constraints. In spite of data limitations, they did detect significant negative impacts on property values.

In the first case, based on a sample of 3,474 home sales, they found that the site influenced property values as far away as four miles; preliminary estimates of the marginal value of increasing a house's distance to the site by one mile was $9,500, and a move of four miles would increase average property values by $14,800.

At the second site, they again found evidence that property values were affected within a four-mile radius of the site. They also obtained statistical support demonstrating the impact of specific perceptual cues (i.e., fires) on the timing of these impacts. Using data from 741 property sales, their estimates revealed that the marginal value of an additional mile of distance from the site was $13,000, rising to $17,600, on average, over a distance of four miles.

In the third study, 6,408 repeat property sales within an urban area were analyzed. This area, in addition to the site of interest, included an oil refinery and more than 30 other hazardous waste sites within a 10-mile radius, all were included in the analysis. In a linear model, the value of an additional mile of distance was found to be $3,435, and preliminary results indicated that the price-distance gradient extended three miles from the facility. The implied values are considerably lower than for the other sites; however, inclusion of the other disamenities possibly allowed the model to more accurately estimate the disamenity value of the particular site, as opposed to the overall disamenity value associated with an industrial area.

## 4.3 Risk Perceptions and Property Values

Evidence that perceptual cues and the social amplification of risk beliefs underlie the erosion of property values around hazardous facilities is convincing. Recognizing the important effect of public risk beliefs on real estate markets, McClelland et al. (1990) combined home sales data (including structural and neighborhood characteristics) with survey data measuring neighborhood risk beliefs for residents living near a hazardous waste site in California. Their data included home sales within approximately a 1.5 mile radius of the site over a 28 month period (August 1983-December 1985). During this time, the site was both added to the NPL (January 1984) and permanently closed (October 1984). By collecting and utilizing neighborhood specific data on risk beliefs, McClelland et al. were able to examine more directly the influence of risk perceptions and attitudes on the sale prices of homes. They estimated that, on average, housing prices would have been higher by $9,794 or 7.2% in the absence of the hazardous landfill, a figure consistent with the magnitude of effects measured by Harrison and Stock (1984). Inflating this value to reflect price level changes yields a 1993 average value estimate of $13,175 for the negative impact on property values due to the hazardous landfill.

Drawing on the ideas of McClelland et al., Reichert et al. (1992) used both a mail survey and county assessor data to investigate the effects of nearby sanitary landfills on property values. They constructed small geographic neighborhoods and used distance as a proxy for the disamenity associated with the landfills. Their results suggest that homes within a 15-18 block distance from a landfill averaged losses of $6,000; homes within sight of the landfill averaged losses of $8,000. Although these were not classified as hazardous landfills, it is interesting to note the problems most frequently identified as concerns to nearby residents. Odor and unattractiveness were cited as significant problems by 39.8% and 37.3% of respondents, respectively. Toxic water runoff was a concern of 34.5%, and 32.6% responded that methane gas appeared to be the most significant problem associated with the landfill. Perceptions of nuisance and health effects are likely to be more pronounced near an NPL site and, therefore, these concerns are likely to increase among residents near hazardous waste facilities.

A contrasting study by Bleich et al. (1991) used negative results to demonstrate the importance of neighborhood risk beliefs near a site. They conducted a property value study to investigate the effects of sanitary landfill design on a residential community. In this example, the landfill was recently designed and constructed to minimize its visibility and impact on the surrounding neighborhood. After controlling for a variety of structural factors, no statistically significant impact from the landfill on local sale home prices was detected.

A comparison of the property value effects from both hazardous and non-hazardous waste sites is presented by Thayer et al. (1992). In their study, 2323 home sales in Baltimore, Maryland were used to examine the relationship between housing prices and several environmental indicators, including proximity to both hazardous and non-hazardous waste sites. Their results support other findings that the effect declines with distance and is limited to a range of less than four miles. They estimate a price gradient of $2,194 per house per mile (1985 dollars) for homes near hazardous waste disposal sites. However, the price gradient falls to $661 per house per mile for homes near non-hazardous waste sites. This is a fairly striking difference in estimated price gradients, which highlights the strength of risk beliefs over and above aesthetic impacts as a perceptual cue.

Further evidence underscoring the importance of strong perceptual cues is found in an examination of the effects of groundwater contamination on property values (Page and Rabinowitz, 1993). The authors found no evidence that residential properties were affected by the presence of contaminated groundwater (although the potential for liability was sufficient to significantly affect industrial and commercial properties). In a similar study, Malone and Barrows (1990) found that nitrate contamination of wells appeared to have little or no impact on the value of residential property in Wisconsin. The absence of a detectable impact on property values in these studies is attributable to (1) weak perceptual cues (i.e., the low level of perceived liability or health risk on the part of homeowners), and (2) the ready availability of substitute water supplies.

### 4.4 The Effect of NPL Status on Property Values

The link between public perception of a hazardous waste site and the impact on property values is further supported by Kohlhase (1991). From an examination of the effect on property values of 10 hazardous NPL facilities in the Houston area over three time periods (1966, 1980, and 1985), Kohlhase concluded that the announced listing of a site on the NPL created a "new market for safe housing." Assembling data from the Society of Real Estate Appraisers and the Census for 1960 and 1980, and constructing variables reflecting distance to the nearest hazardous waste facility and to the central business district, Kohlhase estimated a statistical model using over 4800 pooled observations. She found that the only statistically significant negative impact from the hazardous facilities occurred in the 1985 sample, after sites were listed on the NPL. She concluded that NPL status and its associated media exposure contributed to the public's risk perception and the subsequent decline in property values within six miles of the nearest site. The estimated marginal impact of the sites declined with increasing distance. For example, within a mile of a site the value of increasing distance by one mile was estimated at $4,940, if located one mile from the site the marginal value of an additional mile was $4,259, at two miles the marginal value was $3,466, at three miles $2,606, at four miles $1,660, and $690 at five miles.

## 4.5 The Extent of the Property Value Effects from Hazardous Waste Sites

As argued in Chapter 3, the extent of the market depends on (1) the strength of perceptual cues such as local terrain, visibility, odors, media exposure, and proximity to other amenities or disamenities (e.g., industrial zones), and (2) a significant nearby population which can facilitate the social amplification of risk beliefs. The distance (or market size) over which property values may be affected by a disamenity such as a hazardous waste facility is one of the largely unresolved issues in property value studies. Whereas some researchers (Kohlhase, 1991; Smith and Desvousges, 1986; Smolen et al., 1992) find empirical support for effects at a distance of six or more miles, other studies have found effects only in the immediate area around a site (Harrison and Stock, 1984; Schulze et al., 1986; Reichert et al., 1992; Michaels et al., 1992). In the studies supporting a greater distance effect, the models often lack controls for other potential disamenities such as industrial zoning. These are likely to contribute to the observation that market effects extend beyond immediate areas.

## 4.6 Evidence from Aggregate Level Studies

Evidence from aggregate or regional level property value studies supports much lower average property value losses than the micro level studies previously discussed. This divergence is largely attributable to the lower resolution of the aggregate data and the coarseness of the variable used as a proxy for the disamenity. Typically, the variable of interest is a measure of the number of hazardous waste sites within a given region (e.g., county). The model then estimates the effect of the number of sites on some average measure of regional property values. However, as demonstrated in the micro-level studies, the property value effects of NPL sites are highly localized and encompass a much smaller area than a county. Therefore, the estimated property value loss in aggregate-level studies is probably diluted and not representative of losses in proximity to the site. For example, if 20% of homes in a county incurred an average loss of 10%, the average loss observed in an aggregate level study would be 2%. This suggests that the estimates derived from aggregate studies are not inconsistent with loss estimates from micro level studies. However, their estimates of per household losses for homes near the site are biased downwards.

Using 1980 Census and property data from 64 municipalities in New Jersey, Ketkar (1992) estimated the effect of the number of hazardous waste sites in each municipality on median property values. His estimates ranged from $1,300 to $2,000 per home (in 1980 dollars) depending on the specification of the model (approximately 2% of the median property value of $64,000).

Walker and Hoehn (1993) developed an interregional wage-rent model to estimate the economic damages associated with NPL sites, which they used to rank the sites. In contrast to other property value studies, Walker and Hoehn allow for interregional household mobility, which can affect both housing prices and wages. Using 1980 Census data on workers and households, combined with county-level amenity data, they estimate models explaining both wage and rent variations. Their data consist of 34,353 household observations over 151 counties in the United States, and include data on housing structures, monthly housing expenditures, wages, and county-level amenities such as climate, social, and environmental factors. The 151 counties in their sample contained at least one NPL sites as of December 1990. They included the number of NPL sites in a county as the variable of interest. Their results suggest that the marginal impact of the first NPL site in a community is $106 per house per year (in 1980 dollars), which falls to zero by the ninth site.

These values appear low relative to values obtained in studies using sales level data from more recent time periods. It seems implausible that data collected prior to CERCLA (which was enacted in 1980) would detect the strong signals associated with NPL status; therefore these values are more likely to reflect some general disamenity characteristics. At an aggregate level, assuming a constant damage level across *all* households in the county, Walker and Hoehn estimate annual damages of $14.5 billion (in 1980 dollars). Accounting for inflation, this amount in current 1993 dollars is in excess of $25 billion per year. Using their reported discount rate of 6.85%, the total capitalized value in 1993 dollars amounts to $315 billion. This number is likely to exaggerate the true level of property value losses for two reasons. First, they assume that the effect of a single site spans the full extent of the county -- a distance far greater than detected in micro level hedonic studies. The second reason is the probable colinearity between NPL sites and regional industrialization, which explains why the authors were able to estimate an effect using pre-CERCLA data.

### 4.6 How Well Do Property Value Losses Approximate WTP?

An extensive review of the hedonic property value (HPV) literature reveals that property value losses often exceed $10,000 for homes near (1 mile or less) NPL sites. These studies are summarized in Table 4.1. The table also includes a number of studies of other non-NPL sites. The studies shown in Table 4.1 are of two types. The majority of the studies estimate the effect of distance (or perceived risk from a site) on sale price of homes (described in the table as HPV studies). A few studies estimate the average property value effect on homes in a prescribed area as a function of the number of sites in the area (described as HPV-average). This is

| Table 4.1: Summary of Hedonic Property Value Studies | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Authors** | **Method** | **Location** | **Subject** | **Year(s)** | **Sample Size** | **Reported Values** | **Values in 1993 dollars** |
| Harrison and Stock (1984) | HPV | Boston, MA | hazardous waste sites | 1977-81 | 2,182 | $1,600<br>at 1 1/2 miles from site<br><br>$13,500<br>at 1/2 mile from the site | $2,810<br>at 1 1/2 miles<br><br>$23,715<br>at 1/2 mile |
| Ketkar (1992) | HPV average | 64 municipalities in New Jersey | # hazardous waste sites in region | 1980 | 64 | $2,000 / site | $3,500 / site |
| Kohlhase (1991) | HPV | Houston, TX | NPL sites | 1976, 1980, and 1985 | 4,800 | $17,740 @<1 mile<br>$12,800 @1-2 miles<br>$8,542 @2-3 miles<br>$5,066 @3-4 miles<br>$2,460 @4-5 miles<br>$790 @5-6 miles | $23,690 @<1 mile<br>$17,090 @1-2 miles<br>$11,400 @2-3 miles<br>$6,770 @3-4 miles<br>$3,280 @4-5 miles<br>$1,055 @5-6 miles |
| McClelland et al. (1990) | HPV | Monterey Park, CA | NPL site | 1983-85 | 178 | $9,790 (7.2%) in the absence of the site | $13,175 |
| Mendelsohn et al. (1992) | HPV | New Bedford, MA | PCB contamination of harbor | 1969-88 | 780 proper-ties;<br><br>1916 sales | $9,000 per household in nearest zone<br>$7,000 per household in more distant zone | $10,500 per household<br><br>$8,200 per household |
| Michaels et al. (1992) | HPV | 3 unidentified sites | hazardous waste sites | 1: 1983-91<br>2: 1984-91<br>3: 1983-91 | 1: 3,474<br>2: 741<br>3: 1,683 | 1: $14,000 / mile<br>2: $13,300 / mile<br>3: $4,410 / mile | 1: $14,770 / mile<br>2: $14,030 / mile<br>3: $4,650 / mile |
| Michaels and Smith (1990) | HPV | Boston, MA | hazardous waste sites | 1977-81 | 2,182 | $1,150 / mile | $2,225 / mile |
| Reichert et al. (1992) | HPV | Cleveland, OH | sanitary landfills | 1985-89 | 2,243 | $6,000 for homes in immediate vicinity. | $7,000 |
| Rowe et al. (1985) | HPV | Eagle, CO | NPL site | 1985 | 151 | $24,000 per household | $32,050 |
| Schulze et al. (1986) | HPV | West Covina, CA | NPL site | 1983-85 | 185 | $8800 in the absence of the site. | $11,840 |
| Smolen et al. (1992) | HPV | Toledo, OH | hazardous waste site | 1986-90 | 1,237 | $12,000 per mile of distance up to 5.75 miles. | $13,290 |
| Thayer et al. (1992) | HPV | Baltimore, MD | hazardous and non-hazardous waste disposal sites | 1985-86 | 2323 | $2,194 per mile | $2,930 per mile |
| Walker and Hoehn (1993) | HPV average | 253 counties in the U.S. | # of NPL sites in county. | 1980 | 34,353 | $ 107 per year per household per site. | $ 190 per year per household per site. |

important in interpreting the studies since this latter method will provide smaller per household values in determining total losses (which should be averaged over a much larger number of households).

Complete site cleanup (i.e., complete removal of all contaminated substances from the site) would presumably restore property values to former levels. Thus, these property losses approximate the public's willingness to pay for complete cleanup. Two issues, however, cloud the interpretation of these studies.

First, the hedonic rent gradients shown in Table 4.1, in the absence of transactions costs, can only provide upper bound estimates of willingness to pay and total social benefits of complete cleanup of NPL sites (Brookshire et al., 1982; Bartik, 1988). In other words, property value losses will tend to overstate cleanup benefits unless amenity improvements (e.g., perceived risk reduction) represent marginal changes spread over a large area (Freeman, 1974). Given that the perceived changes in risk associated with cleanup may represent marginal changes in the total risk of death households face, this last argument may be relevant in spite of the magnitude of property value losses. In other words, since a capitalized value of annual risk of death on the order of $10^{-4}$ per person can explain observed property losses, the estimated hedonic gradients could be viewed as valuing marginal changes in perceived risks of death. In this case, property value losses do not overstate cleanup benefits. However, it should be noted that NPL sites may create other disamenities than perceived risk and that these may be non-marginal in nature.

To this point, the discussion has ignored moving and other transaction costs associated with buying and selling homes. As Bartik (1988) has demonstrated, with transaction costs, where amenities in a neighborhood have recently decreased (such as would be the case with a nearby site listed on the NPL), property value losses may not overestimate true benefits. Transactions costs reduce the ability of the market to arbitrage perceived risk. In other words, a family with young children, located near an NPL site, may be eager to exchange homes, even at a substantial loss, with an older couple who initially live far away but would be less concerned about the site if they moved near it. However, since the market would force the seller to, in effect, bear all of the transactions costs in this situation, the family with young children may also be unable to afford to pay for moving expenses, commissions, title fees, etc. for the relocation of *two* households.

Second, many studies may not have adequately controlled for the presence of other non-NPL facilities which produce disamenities. If NPL sites tend to be located in industrial areas, nearby homes will suffer property value losses broadly associated with a variety of disamenities associated with those facilities. The effect of distance to a particular NPL site, the proxy variable usually employed in HPV studies, may, under these circumstances, overstate the effect of an NPL site on property values. Distance may capture the overall effect of proximity to an industrial area. Further, the market size, i.e., the size of the area in which property values are affected by an NPL site, may also be overstated. This potential colinearity problem can be avoided by replacing the distance proxy with actual measures of perceived risk and by explicitly incorporating proximity to other disamenities as done, for example, in the study by McClelland et al. (1990). Unfortunately, in surveying the perceived risk of residents living near the OII landfill, McClelland et al. (also reported in more detail in Schulze et. al., 1986) did not survey much beyond one mile from the site. Thus, in estimating market size from the McClelland et al. study one must extrapolate to obtain a three mile radius. This market size is far less than the six miles obtained in the Kohlhase study (1991).

In spite of these potential problems, property value losses are consistent with the view that the public has both a genuine fear of potential health risks from such sites and a substantial willingness to pay for site cleanup.

## 4.7 Conclusions

The evidence from hedonic property value studies tends to support a conservative estimate of economic losses equal to $10,000 per household within about one mile of the site. The extent of the market reflecting economic losses around sites is less understood. In Chapter 6, evidence on the extent of risk beliefs formed by perceptual cues is used to support a crude estimate of the extent of market effects; however, further research is needed to provide credible estimates of the extent of the market.

The extent to which property losses recover because of remedial actions at a site is a direct measure of the benefits associated with that level of cleanup. However, this approach for estimating the benefits of *partial cleanup* has not yet been addressed in the property value literature. Use of the property value approach to estimate the benefits of partial cleanup is not without difficulty; for example, accounting for confounding factors that may arise and/or change over the substantial periods of time needed for remedial action (e.g., on average in excess of 12-15 years).

The market research approach described in the following chapter attempts to estimate preferences for partial cleanup.

# Chapter 5

# MARKET RESEARCH PILOT STUDY

An appropriate level of remediation at most sites, given the considerable expense of complete cleanup of all sites, lies somewhere between "no-action" and "complete cleanup." This is reflected in the contrast between actions taken at the OII Landfill and Suffolk City Landfill (the case studies presented in Chapter 2). Unfortunately, the property value approach is unable to measure the potential benefits of partial cleanup, and presumably reflects an upper bound estimate of benefits associated with complete cleanup (Bartik, 1988). In this section, we describe the results of a market research study in which we derive estimates of households' willingness to pay for partial cleanup of a nearby hazardous waste site. These results are consistent with empirical evidence from property value studies and provide estimates of the benefits of partial cleanup.

## 5.1 Market Research Approach

The market research approach (MRA) has been used in the design and marketing of new products by providing information on individual preferences.[5] This approach is well suited to the problem of measuring individual preferences toward cleanup options at hazardous waste sites, and is useful for deriving estimates of willingness to pay associated with these options (Hartman et al., 1991).

Following the standard lines of the random utility model (McFadden, 1976), we assume that a household decision maker chooses from among the available

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[5] For a discussion of these methods, see Louviere (1994) and the supplemental issue of The Journal of Business, *Interfaces between Marketing and Economics*, 1980.

choices the alternative that maximizes their utility. However, because the researcher is unable to observe all the characteristics of the decision maker, there is a random component to this relationship. Assume that the observed utility of a decision maker can be defined as the sum of a deterministic function of the characteristics and an error term associated with unobserved characteristics. For simplicity, we assume that utility is a linear function of characteristics and is given by:

(1) $$U_{ij} = \beta' X_{ij} + e_{ij}$$

where $U_{ij}$ is the utility that individual i receives from choosing alternative j, $X_{ij}$ is a vector of attributes of individual i and alternative j, ß is a parameter vector, and $e_{ij}$ denotes an error term induced by excluded or improperly measured attributes or random tastes. The individual, by choosing alternative j, reveals that utility from alternative j is higher than from any other alternative. That is, we observe that $U_{ij} > U_{ik}$ for all $k \neq j$. Hence, the probability that individual i selects alternative j is given by:

(2) $$\text{Prob}\,[\,i \text{ selects } j\,] = \text{Prob}\,[U_{ij} > U_{ik}], \text{ for } k \neq j.$$

Suppose that the random components of $U_{ij}$, $e_{ij}$, are independent and identically distributed with a Weibull distribution. It can be shown that[6]

(3) $$\text{Prob}\,[\,i \text{ selects } j\,] = \frac{e^{\beta' X_{ij}}}{\sum_{j=1}^{J} e^{\beta' X_{ij}}}$$

This is the familiar conditional logit model that will form the basis for our estimated results presented later. The estimated coefficients from this model can

[6] See Maddala, 1983.

then be used to derive estimates of the compensating variation associated with a change in the alternative selected. This is accomplished by specifying a utility function for the representative consumer and determining the level of compensation necessary to maintain utility at a constant level.

## 5.2 Market Research Pilot Study

The survey design process involved multiple iterations and quality control steps including a detailed process of pre-testing (e.g., verbal protocols). The use of verbal protocols, where a respondent verbally expresses their thoughts into a tape recorder as they read and answer the survey questions, provides much feedback to the researchers about the design of the instrument. Specifically, insight is obtained with respect to wording problems, scenario rejection, and what information is important to the respondent in making decisions. This systematic methodology in survey design can result in instruments that are carefully tested and suited to the objectives of the study.[7]

In order to develop initial prototype survey instruments that minimized scenario rejection, and to facilitate the design process, a fictitious description of a hazardous waste site and its cleanup alternatives was developed. To make the descriptions as realistic as possible, information was used from U.S. Environmental Protection Agency records and feasibility studies for similar sites. The survey was designed to flow from general issues concerning hazardous waste problems and the

[7] Twenty verbal protocols were conducted, five for each of four survey versions. Combinations of context (type of site and health risk information) and different valuation questions were tested to cover the full range of surveys that might be used in the study. Participants were instructed to respond honestly and openly to the survey questions and that there were no right or wrong answers. They were instructed to talk continuously into a tape recorder and if they were silent for any extended period of time, they were reminded to speak out loud. The responses to the questionnaire, information from debriefing questions, and subject observation provided the basis for improvements and refinements in subsequent revisions in the design of the survey.

Superfund program in the U.S. to increasingly narrower issues pertaining to site-specific problems and remedial activities.

A market research pilot study was conducted with 266 individuals. These individuals, selected by a professional survey research firm, reflected a broad cross-section of the community, with a variety of backgrounds, ages, incomes, and ethnicities. The individuals were provided one of several detailed survey versions describing the hypothetical NPL site. Variants of the survey differed in their subject (landfill versus industrial facility), valuation format, health risks associated with the cleanup options, and prices for the cleanup options.

Respondents were asked to imagine that they and their family lived one and a half miles away from the site. The site was described in detail, including the nature of the contamination, expert assessments of the health and environmental risks, each of five alternative cleanup options and site conditions after cleanup, and the per household costs (presented both as a lump sum and a monthly fee for a 10 year period) that would be required for each alternative.[8] Based on this information, respondents were asked to select their most preferred option as well as their next most preferred option in case their first choice was unavailable.

To test the market research methodology in detail, four versions of the survey describing a landfill NPL site were administered to a subsample of 161 individuals. Variations in the costs of cleanup were provided in different versions of the survey and, in two versions of the survey, complete cleanup was described with an associated health risk related to the removal and transportation of

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[8] To minimize the potential for scenario rejection, the pilot survey excluded the possibility of potential responsible party liability and asserted that every community would be responsible for funding the cleanup activities of their own sites. This scenario, although not consistent with actual CERCLA provisions, does capture the spirit of the Superfund law as it is popularly conceptualized. In none of the verbal protocol or focus group sessions did anyone object to or question this portrayal of the program. Therefore, we believe our results do accurately depict values and perceptions held by the public for hazardous waste cleanup.

contaminants. Five options for cleaning up the hazardous waste site were provided in order of increasing level of cleanup:

Option A: "no action" -- no efforts are taken at the site.

Option B: "institutional controls" -- action is taken to remove immediate health and environmental risks by fencing of the site and finding alternative sources to replace contaminated wells.

Option C: "landfill cap and groundwater filtration" -- action is taken to eliminate off-site exposure risks from surface water runoff and groundwater is treated for use.

Option D: "landfill cap and groundwater barrier" -- action is taken to eliminate off-site exposures as in C above and to prevent further groundwater contamination.

Option E: "complete cleanup" -- actions are taken to physically remove all contaminants to licensed off-site disposal facilities and the contaminated groundwater is pumped, treated, and re-injected into the ground.

Figures 5.1-5.4 illustrate how these different variants of the survey affected the preferred choice of respondents. In particular, observe how the choices for complete cleanup (option E) change in response to changes in complete cleanup cost and risk. The distribution of first choice preferences for the survey version with low cost estimates for the options and no associated risk for complete cleanup is presented in Figure 5.1.

**FIGURE 5.1**
**LANDFILL CHOICE VERSION 1**
(low cost -- no risk with option E)

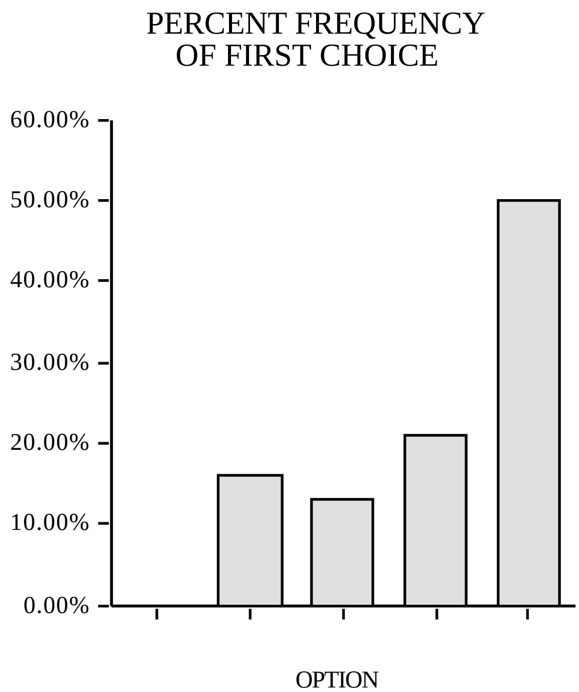



**FIGURE 5.2**
**LANDFILL CHOICE VERSION 2**
(low cost -- risk with option E)

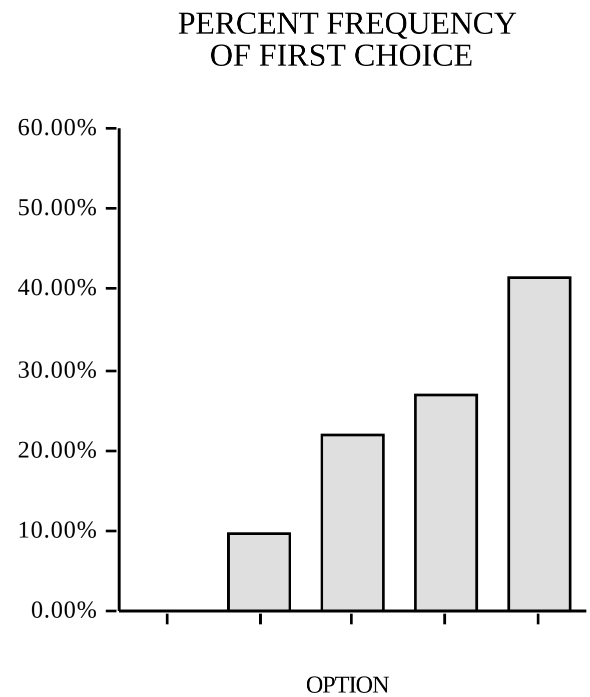



**FIGURE 5.3**
**LANDFILL CHOICE VERSION 3**
(high cost -- risk with option E)

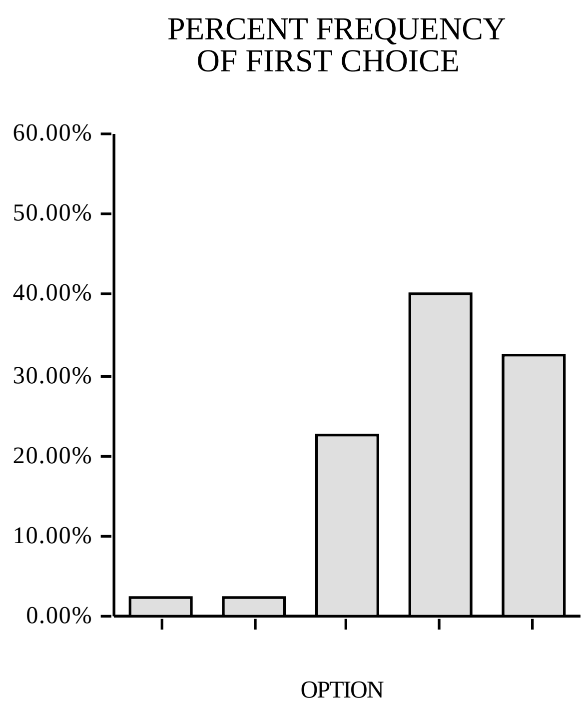
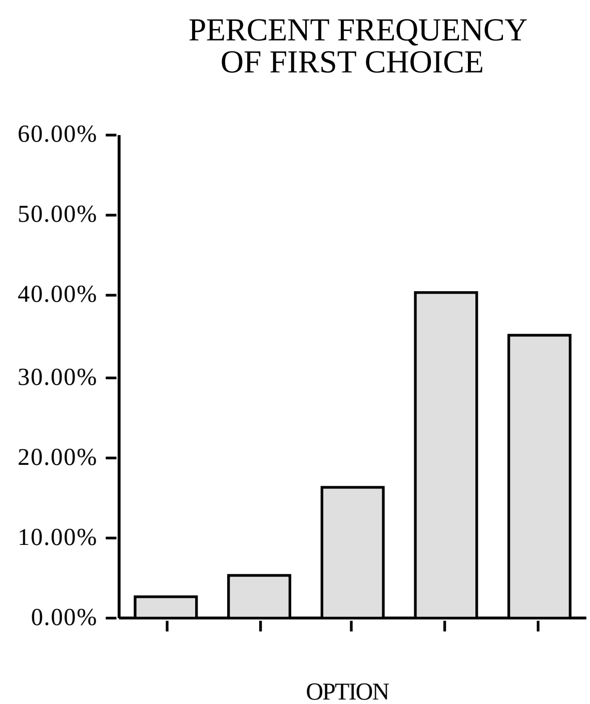



**FIGURE 5.4**
**LANDFILL CHOICE VERSION 4**
(high cost -- no risk with option E)



The results indicate that nearly 50% of respondents preferred complete cleanup with the remaining preferences distributed nearly equally across options (B), (C), and (D). When a slight expert assessment of risk (1 in 10 million) is added to the consequences of complete cleanup the result is a slight shift in choices from complete cleanup toward options (C) and (D), as shown in Figure 5.2; however, complete cleanup is still the most preferred option. When cleanup costs are increased to levels more consistent with actual costs (i.e., $50 per household per month for ten years for complete cleanup) we begin to see the most preferred alternative shift from complete cleanup to option (D)-- landfill cap and groundwater barrier. Figure 5.3 illustrates the choice distribution with the combination of higher complete cleanup cost and risk, and Figure 5.4 illustrates the effect of higher complete cleanup cost alone. In both cases, choices shift away from complete cleanup. The shift from complete cleanup to a partial cleanup in response to the risk associated with implementing complete cleanup is consistent with public preferences demonstrated at the Smuggler Mine near Aspen, Colorado. At this site residents resisted strongly the efforts of EPA to dig up and remove contaminated soil. The community rallied and supported a public referendum against complete removal because this action, it was believed, would most likely expose the community to greater health risks than suggested containment alternatives (Mangone, 1993).

Responses from the survey were then used to estimate preferences using the market research approach described above. The estimation included two specifications of the conditional logit model. The specifications differed in the number of variables hypothesized to affect the choice of a remedial option. Both specifications included cost of the option and risk (in this analysis risks associated with complete cleanup were zero); however, specification 2 added respondent characteristics. The estimated coefficients from these two models were then used to derive willingness to pay estimates for each option (see Hartman et al., 1991 and Volume II of this report for a description).

The results are presented in Figure 5.5, which shows high and low estimates based on the two specifications of the maximum monthly premiums that households would be willing to pay for each option relative to doing nothing at the site (i.e., the "no action" alternative). For example, the low estimate of implied willingness to pay for "institutional controls" at an uncontrolled site is approximately $111/month. The value of moving from "institutional controls" (i.e., the status quo position presented in the survey) to option E ("complete cleanup") is approximately $93/month (i.e., $204 - $111). For comparison to the property value estimates (which approximately capture the value of moving from institutional controls to the complete cleanup option), we estimate the capitalized value of this stream of payments over the 10-year payment period using a capital recovery factor of 13% (this is consistent with mortgage interest rates in the early 1980s when most of the property values studies were conducted).[9] This results in estimates of low and high capitalized values of $8,589 and $11,288 per household, respectively. This value estimate is consistent with estimates of property value losses.

Another important result is shown in Figure 5.5. The value associated with Option D (as compared to institutional controls) ranges from 60% to 90% of the value held for complete cleanup. Therefore, at sites where significant economic damages are implied, these results suggest that between 60% and 90% of the value of complete cleanup can be obtained with actions such as capping and a groundwater barrier. Given the large costs associated with complete cleanup, our analysis

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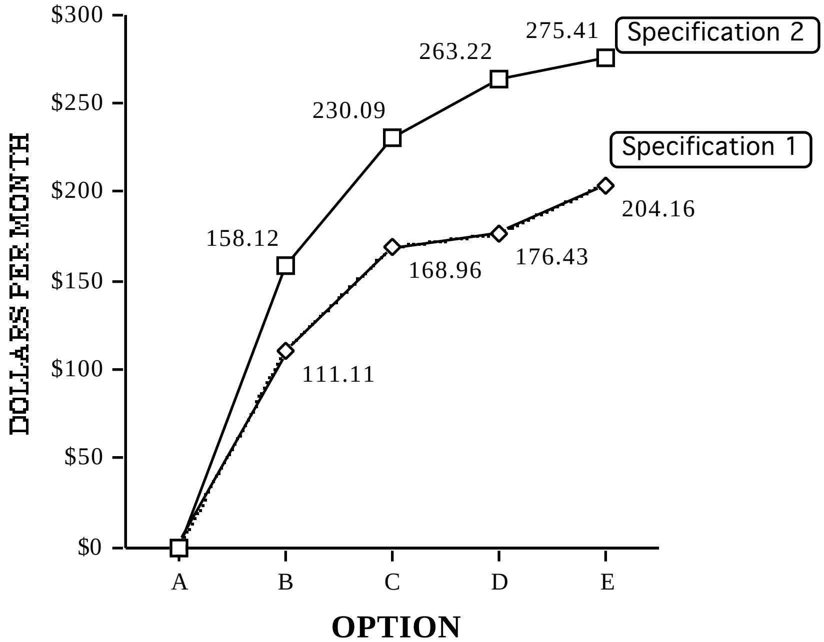
[9] We use a 10 year payment period because the average U.S. household moves within 10 years. Thus, respondents would, on average, not expect to live near the study cite beyond 10 years.

**FIGURE 5.5**

## WILLINGNESS TO PAY FOR CLEANUP OPTIONS
## (LANDFILL CHOICE SURVEYS)




**OPTIONS:**

**A** -- No Action
**B** -- Institutional Controls
**C** -- Soil Cap and Water Filtration
**D** -- Soil Cap and Groundwater Barrier
**E** -- Complete Cleanup

suggests that, in most cases, complete cleanup cannot be supported on economic grounds.  However, evidence from this pilot study also indicates that complete cleanup is not always preferred by the public, particularly when the economic costs are very high and there is greater risk associated with complete cleanup compared to containment alternatives.

When the choices given to respondents contain a description of the expert assessment of risks, costs, and the likely results of the alternatives, the resulting choices can be used to estimate both preferences and values.

To this point, we have examined the micro-level consequences of NPL sites on local risk beliefs and property values. We have shown that property value losses are both plausible from the perspective of public risk beliefs and measurable with objective methods of assessment.  Results from our pilot market research study further reveal that intermediate, and less costly, remedial strategies can quite often be acceptable to the public.  What are the implications of these micro-level concerns for national level policy?  We are now equipped to consider this question.

## Chapter 6

# A PRELIMINARY ASSESSMENT OF SOME ECONOMIC BENEFITS OF SUPERFUND CLEANUP

In the previous chapters we presented a market research model of community preference estimation and demonstrated its consistency with the available literature on the benefits of hazardous waste site cleanup. At this disaggregate level we found that the economic impacts of a hazardous waste site on the surrounding community can be significant and contribute to a measurable loss of welfare. In this Chapter we adopt a national level perspective on the economic issues of Superfund cleanup, and attempt to aggregate our findings on benefits and costs. By providing a broad assessment of the benefits and costs of Superfund cleanup, we intend to indicate an appropriate level of response which is both consistent with the public's values and considerate of the opportunity costs of scarce cleanup resources.

Upper and lower bound estimates of aggregate net benefits of partial Superfund site cleanup are developed based on several parameters. These include: (1) estimated property value losses (Chapter 4), (2) the market research pilot study (Chapter 5), (3) the proximity and distribution of households near NPL sites, and (4) the distribution of estimated cleanup costs (CBO, 1994).

In our national assessment of benefits we retain -- to the greatest extent possible given available data -- this sensitivity to the distance and density of households within the affected region and to the relative value of partial cleanup compared to complete cleanup. In developing these estimates we relied extensively on the population and distance information contained in the NPL Characterization Project Database (ICF, 1992).[10]

This analysis is broad in both its scope and its methods; as such, it necessarily overlooks other potential sources of benefits which may be important at particular sites. For example, this analysis ignores issues associated with non-use and recreation benefits which, given the nature and location of most NPL sites, are likely to be of second-order importance and unlikely to change our order-of-magnitude estimates substantially. From the information on public preferences presented earlier, the primary benefits to cleanup arise from the restoration of local property values. We assume that local property values can be partially restored by remedial activities taken at sites, which to our knowledge, has not been accomplished by risk communication.

## 6.1 Estimating the Extent of Market

Property value effects depend on the extent and pattern over distance from the site, independent of the effects of other local amenities and disamenities. Economic losses that occur from living near a NPL site are well documented in the literature on property values. However, one important issue, the extent of the market, is not adequately addressed. In this section, we examine the issue of market extent and construct a simple property value gradient model which is used to derive national level benefits.

### The Extent of Property Value Losses

In hedonic property value studies, the extent of the market is defined by the distance over which losses occur. Usually, the distance variable in such studies

10 This database provides information on population within one mile for 680 sites and within three miles for an additional 287 sites (967 sites in total).

serves as a proxy for perceived risk; however, in practice, the distance variable may also proxy for other nearby amenities and disamenities. Walker and Hoehn (1993) recognize the importance of wages in determining the location decisions of households, particularly at a macro level, where a wider degree of substitution in the choice of housing location may be theoretically plausible. However, this aggregate approach does not and cannot detect the largely localized character of most property value effects associated with hazardous waste sites as demonstrated by Ketkar (1992). By counting the number of hazardous waste sites in a region or county, these aggregate studies may be measuring the disamenity values for industrial areas in which hazardous waste sites are typically located.

A similar argument can be raised with respect to several of the area-wide / multiple-site studies (e.g., Kohlhase, 1991; Mendelsohn et al., 1992; Michaels and Smith, 1990). These studies have shown property value losses as far as six miles from sites. One reason that the supposed effects of NPL sites appear to extend over such a large distance may be that other disamenities in the vicinity have not been taken into account. For example, Kohlhase does not allow for the significant effect of other industrial sites in her specification. The likely location of NPL sites within industrial sectors of a city (e.g., Houston) makes this an important consideration in modeling spatial variation in property values. This mis-specification (i.e., from omitted variables) could account, in part, for bias in the estimation of a gradient that extends to six miles, which is far beyond the influence shown in other studies that measure perceived risk (e.g., McClelland et al., 1990 and Schulze et al., 1986), and studies that incorporate the effects of other local disamenities (e.g., Reichert et al., 1992; and Michaels et al., 1992).

**A Useful Approximation of Market Extent**

The extent of the influence of perceived risk (and its related effect on property values) is likely to vary by site and is not easily identified without considerable location-specific research. This fact is recognized by many of the authors of property value studies; however, attempts to measure the extent of property value losses have produced questionable results. To address this issue, we construct an approximation for the extent of market influence. This approximation is derived from the empirical evidence of risk perceptions in Schulze et al. (1986) and from the estimated hedonic property value function in McClelland et al. (1990).

Evidence on the extent of subjective risk perception around the OII Landfill provides one of the clearest illustrations of the affected market in the available literature; however, the full extent of the property value effects is not explored. Therefore, the distance at which perceptions of high risk from the site fall to zero is constructed based upon the evidence on public perception of risk by distance (Figure 7.13 in Schulze et al. 1986).[11]

A linear extrapolation of risk perception is constructed based upon the scale of blocks in the area (1 block equals 330 feet). This is shown in equation (1):

(1) $SR = 0.745 - 0.251r,$

where SR is the share of households with high risk beliefs, and r is the distance/radius in miles. Setting SR to zero results in a distance of nearly three miles. McClelland et al. (1990) use this measure of risk perception to estimate the impact of neighborhood risk beliefs on property values. This evidence can be used to

[11] The data suggest that 66.3% of individuals at a distance of 5 blocks perceive a high level of risk from the site. This risk perception falls to 43% at an average distance of 15 blocks. A linear extrapolation suggests that risk perception falls by 2.3% for each block. Assuming an average block is equivalent to 660 ft. the distance at which high risk perceptions would be expected to fall to zero is 3.0 miles.

construct a property value gradient that is directly related to risk beliefs. Based on the estimated relationship in McClelland et al., the estimated property value gradient is given as:

(2) $L(r) = 20{,}839\ (0.745 - 0.251r) = \$15{,}525 - \$5{,}230r$,

where L(r) is the loss in property value ($) as a function of distance (r) to the site. For example, a home located at the site boundary (i.e., r=0) is estimated to suffer a loss of $15,525.

The range of empirical evidence is not clear on either the shape or the slope of the distance gradient of property as shown in Figure 6.1. This figure contrasts the gradient implied by Kohlhase (1991) with the gradient based on Schulze et al. (1986) and McClelland et al. (1990) developed above. Each gradient in Figure 6.1 illustrates how property value losses fall with distance from the site. The dotted lines associated with the Schulze-McClelland curve indicate the range of distances over which the data were extrapolated. The extrapolation was minor with respect to distances close to the site; however, the extent of extrapolation is significant beyond one mile from the site.

Losses within one mile of a site are well documented (see Table 5.1) and are reasonably consistent as shown in Figure 6.1. Uncertainty about the shape and magnitude of the gradient increases significantly beyond one to one and one-half-miles from the site, and estimated gradients are likely to reflect functional specifications in the statistical model (e.g., linear, log-linear, quadratic, etc.). In any case, very large losses can occur near NPL sites.

**FIGURE 6.1**

## A Comparison Between Property Value Losses by Distance and the Market Research Results

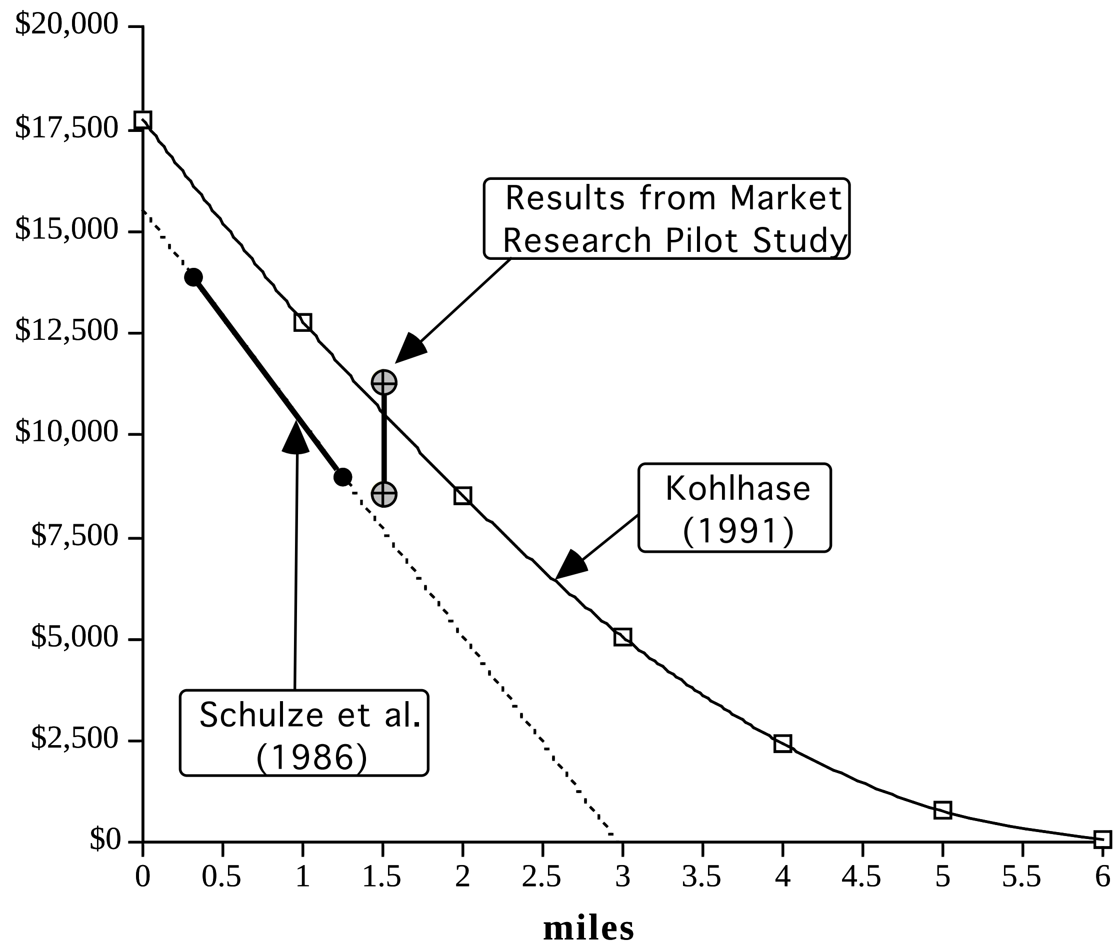



Figure 6.1 also illustrates the evidence of economic loss from the pilot market research study; estimated capitalized values for complete cleanup range from $8,589 to $8,875 for households living one and one-half-miles from the site. The values obtained in the market research study are remarkably similar to values obtained in the property value studies.

### 6.2 A Lower Bound Estimate of Aggregate Benefits

In developing a lower bound estimate of partial cleanup benefits, our goal was to use only the most conservative assumptions where necessary. Using available information on population and distances for a large subset of actual NPL sites, we construct estimates of total national benefits associated with the partial cleanup of NPL sites using the following assumptions:

(1) Only households within one mile of the site are adversely affected,

(2) There are 2.63 individuals per household (U.S. Census, 1990),

(3) Average loss per household is $10,000.

The extent of the market effects is uncertain and, given the estimates of public risk perception in Schulze et al. (1986), it seems implausible that it is less than one mile. However, we use this conservative estimate to clearly encompass the lower bound level of benefits of partial cleanup.

A lower bound estimate of property value losses is constructed for each of the 680 sites with information available on one-mile populations (ICF, 1992) as:

(3) Property Loss / Site = POP1 / HH * $PV

where: POP1 = population within one mile of the site,
$PV = average economic value per household (assumed to be $10,000),
HH = 2.63 individuals per household (1990 estimate)

The aggregate estimate is derived by summing across each of the 680 sites and adjusting proportionately upward to reflect an overall estimate of 1157 non-federal NPL sites (i.e., multiplying the sum by 1157 / 680). This procedure yields a lower bound estimate of total property value losses of $21.4 billion. This figure represents the total impact of the site on property values and measures the benefits of complete cleanup up at all sites.

To estimate the lower bound benefits of partial cleanup, we adjust the above estimate by using the lower bound estimate from our pilot study. This is that 70% of the benefits can be obtained with significant partial cleanup. The benefits of partial cleanup are then given by Equation (4):

(4) B = 0.70 * TL.

This adjustment results in a conservative estimate of partial cleanup benefits of $15 billion. As stated previously, by limiting attention to within one mile of a facility, this estimate minimizes the extent of market effects and captures only the loudest market signals reflected in a hedonic price gradient. Furthermore, the data are also likely to reflect the presence of other factors which limit actual populations nearest NPL sites; these could include zoning restrictions or site locations within industrial sectors. Thus, this estimate completely ignores the effects on larger population densities more than one mile from a site.

In constructing an upper bound estimate, we accommodate many of these concerns to design a model which is sensitive not only to the declining marginal effect of the site with distance but to the rising marginal population with distance.

### 6.3 An Upper Bound Estimate of Aggregate Benefits

A more sophisticated approach to assessing site-level benefits addresses two important concerns. First, in constructing this estimate we take into account the gradient of property value losses at the site. Both theory and empirical evidence show that values fall with increasing distance. We assume a three mile radius for the upper bound estimate of market size and employ the property value loss function developed in Section 6.1. Second, we make adjustments to the one mile population data which accounts for rising population with distance from the site. Such adjustments are required due to a lack of three mile population data (available for only 287 sites). An increase will occur because surface area is proportional to the square of distance, and thus -- assuming constant lot size -- population can be expected to rise by at least the square of distance. This simple approach is likely to understate the population gradient because (1) the area of the site (where people are assumed not to live) is not accounted for, and (2) in moving farther from an industrial site, in general, there is an increased likelihood of residential zoning.[12] Assuming that risk belief patterns diminish uniformly with distance from the site, total property value losses (TL) are a function of population density ($D_i$) and distance (r) and are estimated by:

$$(5) \qquad TL(D_1, D_2, r, r_0) = 2\prod \int_{r_0}^{1} L(r)\, D_1\, r dr + 2\prod \int_{1}^{3} L(r)\, D_2\, r dr,$$

where $D_1$ and $D_2$ are the density of households (i.e., #households / area) between the site and one mile, and between one and three miles from the site, respectively. $r_0$ is the distance of the nearest homes to the site, and L(r) is the property value loss as a function of distance (equation (2)).

Estimates of total losses were constructed for each of the 967 NPL sites available from the database.[13] These estimates were then summed, and adjusted for the population of 1157 non-federal NPL sites. The resulting upper bound estimate of total property value losses is estimated at $89.3 billion. As in equation (4), we adjust this estimate to reflect partial cleanup benefits, except that in this case we assume that 90% of total benefits can be obtained with a partial cleanup, consistent

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[12] Based upon calculations from 128 sites in the NPL Characterization Project Database (ICF, 1992) for which there were both one and three mile population information, the ratio of three-mile population to one-mile population was nearly 24. This number, however, likely overstates the population within three miles of a site because it would imply that nearly one half of the households in the United States live within three miles of an NPL site, a figure that does not appear to be credible.

[13] In cases where either of the population estimates were not available we assumed a constant density of households throughout the 3 mile radius based upon the available population data. Similarly, in cases where the distance from the site to the nearest population was missing, we assumed the sample average distance of 567 ft.

with our upper bound market research results in Chapter 5. This yields an estimate of $80.4 billion for the partial cleanup of all NPL sites.

This estimate of benefits probably exceeds the actual level of benefits due primarily to the process of community risk belief formation and transmission (this process was described in detail in Chapter 3). The amplification of community risk beliefs depends on the strength of perceptual cues associated with the site and the density of the population exposed directly to these cues. These conditions will vary widely across the sample of NPL sites. They will be weak or non-existent at many sites where, because of zoning or local conditions, few or no residents live in the area where perceptual cues are strongest. Our assumptions will tend to overestimate benefits at these sites because the absence of nearby residents reduces the strength of the perceptual signal that is conducted to more distant residents.

## 6.4 Distribution of Benefits

To illustrate how these estimated benefits are distributed, frequency histograms are constructed for both the lower and upper bound estimates. Using a linear scale to arrange benefit estimates in intervals of $20 million, Figures 6.2 and 6.3 show the distribution of lower and upper bound benefits, respectively. Both distributions clearly show that the per site benefits derived from partial cleanup are less than $40 million for the majority of sites.

Figures 6.2 and 6.3

This simplified analysis suggests that approximately 25% of the sites on the NPL are associated with over 80% of the property value losses. A summary of the upper and lower bound estimates is presented in Table 6.1.

**Table 6.1**

**Upper and Lower Bound Estimates of Property Value Losses and Benefits of Partial Cleanup Associated with NPL Sites (billions of $)**

| Sample | Total Property Value Loss | Benefits Of Partial Cleanup |
|---|---|---|
| Upper Bound | $89.3 | $ 80.3 |
| Lower Bound | $21.4 | $ 15 |

The distributions are depicted using a geometric scale in Figures 6.4 and 6.5. The intervals for the geometric scale double in size with each successive interval, beginning with the frequency of sites with less than $750,000 in estimated benefits up to the frequency of sites exceeding $400 million in benefits.

Figures 6.4 and 6.5

## 6.5 The Distribution of Expected Cleanup Costs

The most comprehensive attempt to date to estimate and forecast the costs associated with the Superfund program is documented in a recent report by the Congressional Budget Office (1994). This analysis encompasses the full range of costs, including legal and administrative costs, and details a dynamic time-path for cleanup such that cost estimates are derived in terms of present values. The CBO study considers a number of factors in developing representative costs including past experience with remedial costs (both capital plus operation and maintenance), the potential number of sites to be added to the NPL in the future, and the distribution of costs across sites. Because of the wide range in costs associated with site cleanups, the report considers three cost categories for sites:

--minor sites -- where present worth costs are less than $20 million,
--major sites -- where present worth costs are between $20 and $50 million,
--mega sites -- where present worth costs are greater than $50 million.

These categories are based on estimates from Records of Decision for sites where remedial action decisions have been made. In deriving average cost estimates for each category, the CBO assumed a growth adjustment factor which reflects the trend that actual costs often exceed projected costs for projects finished to date. The average present value costs for cleaning up sites within each category are: $21 million for minor sites, $50 million for major sites, and $169 million for mega sites. In applying these average costs, the CBO made several assumptions about the distribution of sites across the categories. Available data suggest that the distribution of sites across cost categories is not constant but is shifting away from the higher cost categories as a larger share of the worst sites are increasingly identified.

For the present purposes of comparing the costs and benefits associated with the present list of non-federal NPL sites, we use the CBO's estimated cost distribution for the first 711 NPL sites. These are 74.8% minor, 18.7% major, and 6.5% mega sites. This information is used to approximate a continuous distribution of costs. In this approximation, we assume that costs are distributed log-normally and that the share of sites within each cost category is preserved. The fitted distribution was then used to construct a frequency histogram of costs similar to the frequency histograms of benefits shown in Figures 6.2 and 6.3. The approximated frequency distribution of costs is presented in Figure 6.6.

## 6.6 A Comparison of Benefits and Costs

Assuming that the cost and benefit distributions are independent, we can examine the likelihood that benefits exceed costs for cleanup at a particular site. This assumption is plausible since the benefit distribution is based on proximity to populations, the cost distribution is largely driven by the scale of contamination, and the correlation between scale and proximity is not expected to be strong, a priori.

A joint probability distribution of costs and benefits was constructed for both the lower (Figure 6.2) and upper (Figure 6.3) bound estimates of benefits. In constructing the approximate joint distribution, we used the eleven ranges exhibited in Figures 6.2 and 6.3, and computed the likelihood of each combination. By considering only those combinations where benefits are expected to strictly exceed costs (e.g., benefits of $60-80M are combined with costs of <$20M, $20-40M, and $40-60M) we can estimate the likelihood that site cleanup would satisfy a strict benefit-cost test. This is a reasonable test for approximating an economically efficient level of effort because at a social optimum net benefits are maximized; this optimum is characterized by benefits which are strictly greater than costs. Using the upper bound distribution of benefits, this likelihood is estimated to be 0.39; the lower bound distribution results in an estimate of 0.13.

Figure 6.6

# Chapter 7

## CONCLUSIONS AND POLICY IMPLICATIONS

In this report we have covered a considerable range of issues relating to the economic impacts of hazardous waste sites. In summary, we have:

--shown the acceptability of remedial strategies that perform less than "complete cleanup;"

--described how risk beliefs are generated and affected;

--presented the available empirical evidence on the magnitude of property value losses and the extent of the market effects from NPL sites;

--described the market research approach and how it can be applied to the assessment of community preferences;

--compared market research results to estimates from the property value literature;

--shown how the public's assessment of expert credibility can effect risk beliefs and explain the observed magnitude of property value losses;

--constructed a national assessment which considers the distribution of both benefits and costs.

Several preliminary conclusions can be drawn from this research:
(1) much more stringent criteria should be developed for placing sites on the NPL;
(2) our pilot study results suggest that many people are satisfied with options other than complete cleanup, particularly when there are risks associated with complete

cleanup from the removal of hazardous substances; (3) the magnitude of welfare losses estimated in the pilot study are consistent with estimates from the hedonic property value evidence; (4) preliminary analysis estimating the national economic benefits of partial cleanup at NPL sites found that approximately 25% of the sites on the NPL are associated with over 80% of the property value losses. Furthermore, the percentage of sites satisfying a benefit/cost criteria likely falls between 13% and 39% of all non-Federal sites currently on the NPL. This evidence suggests that greater flexibility should be incorporated into the selection of remedial action alternatives at NPL sites, especially when future land-uses of sites and the size of nearby populations are considered. In particular, Viscusi and Hamilton (1994) have shown that expert estimates of risks from these sites depend critically on assumptions made about future land-uses. Our market research pilot study suggests that the public finds cleanup strategies that limit future land-uses (e.g., residential uses are prohibited), but eliminate off-site risk (such as capping a site and controlling groundwater movement), are acceptable.

Although current EPA policy does in fact show considerable de facto flexibility (as demonstrated by our comparisons presented in Chapter 2 between the OII Landfill and the Suffolk City Landfill), that flexibility has not formally been incorporated into Superfund legislation. A formal mechanism for incorporating flexibility in selection of remedial action and a systematic method for incorporating public preferences into the remediation process would be desirable.

Most of the available evidence suggests that people living near NPL sites believe that the sites present a real risk to themselves and to their families. These beliefs result in welfare losses to individuals and communities. These welfare losses are often expressed as lower property values in addition to increased stress and anxiety. Because these economic losses are real, and because we live in a democratic, free market society, it is the subjective risk beliefs of the public, not the subjective beliefs of experts, that are relevant for public decision making. However, NPL listing of a site appears to exacerbate the fears of nearby citizens. Instead of providing the quick cleanup implied by the concept of a "fund," Superfund has instead resulted in lengthy delays and continuing property value losses. By placing a site on the NPL, the EPA is, in effect, telling nearby citizens that they are in danger. Although listing new sites (unless a serious immediate risk is present) would send the wrong signal, delisting sites already on the NPL would very likely leave nearby residents feeling outraged and abandoned. Just as risk communication has failed to convince the public that off-site risks are negligible, delisting sites will most likely be viewed as an attempt to sweep the problem under the rug.

The literature on conflict resolution and risk communication provides guidance on how to incorporate public preferences into public decisions. For example, a Citizen Committee that consists of community leaders who are broadly representative of community values might be formed at each NPL site soon after a site is listed. This committee could follow a four-step process wherein, first, information is disseminated to the community on the technological choices available for cleanup. Unless the public is fully informed of alternative options, it is likely to demand complete cleanup of the site and be unaware of acceptable lower cost alternatives, adoption of which would speed cleanup. To develop these options, the committee should appoint a panel of technical experts. The technical experts must be careful not to incorporate their own value judgments into the list of alternatives because it is not the job of the experts to choose the remedy. Problems that involve complex technical issues can make it difficult for citizens to participate in the policy process (Verba, 1969; Abrams and Primack, 1980). Therefore, it is the job of the Citizen Committee to explain these cleanup options to the public in a way that is comprehensible to the average layperson.

Second, the committee can disseminate information to the community on the risks associated with each of the technical options, including a no action option. To obtain estimates of these risks, the committee should appoint a second expert panel. Again, it is not the role of this panel to suggest a remedy.

Third, once the public has been informed by a credible source (the Citizen Committee) of cleanup options and risks, the committee should solicit public preferences concerning the available cleanup options. This can be done through public hearings, survey research, etc. In order for the open process to have effective participation, equal time must be given to both societal and political concerns (Stewart et al., 1984).

Finally, the Citizen Committee can make specific recommendations concerning the appropriate remedial action. Studies that have been conducted using similar methods resulted in more successful outcomes when all sides were able to present their concerns regarding risk levels, weigh all the options, and then choose an alternative (Hammond and Adelman, 1976). The more involved the public is with the decision making process, the more satisfied it will be with the cleanup action chosen.

It is our view, based both on existing experience and our pilot study of public preferences, that a process such as the one outlined above could both speed cleanup and result in the selection of less costly remedies which satisfy the public.

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