Challenges in Applying Property Value Studies to Assess the Benefits of the Superfund Program

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Executive Summary

This report discusses the theory and applicability of hedonic valuation, and reviews the challenges inherent in applying available property value studies to assess the benefits of the Superfund program. In doing so, the report also provides a literature review of the research into changes in residential property value associated with hazardous substance contamination at Superfund sites. A few studies on property values associated with general hazardous waste were also considered. Although the existing Superfund literature focuses specifically on National Priorities List (NPL) sites, this report discusses both NPL and non-NPL sites in the Superfund program.

The literature review yielded the following findings:

- Many studies find that NPL sites have an impact on surrounding residential property values, but the impacts found vary in size and direction.
- Information on timing and attribution of price effects is unclear and not the question most of the existing studies investigated.
- In cases where homes near an NPL site experience a decline in price associated with site proximity, there is some evidence that there may be a reversal of the decline after the site is listed and before the remedial action is complete.
- The existing literature does not provide enough information to estimate the benefits of the Superfund program as a whole nor to estimate the benefits of the NPL.

Existing studies (with a few exceptions) rely on data that do not isolate individual actions along a site's timeline that could cause the evaluated price effect. The studies usually identify a single key event, that varies from study to study, and look at price effects before and after that one event. Most studies do not distinguish among the full set of events associated with an NPL cleanup; for example whether price information was collected at a time when contamination had just been discovered; the site was listed on the NPL; or Superfund assessment and cleanup activities were underway or completed. This and other factors which we will explain below suggest that the studies are ill-fitted to the task of identifying causal linkages between the price effects they evaluate and the impact of the Superfund program as a whole. One study (Greenstone and Gallagher 2008) uses an approach which avoids this problem, but it relies on self-reported, geographically coarse data (as opposed to the observed sale prices used in other studies). Two studies that carefully distinguish between different events at an NPL site (Kiel and Zabel 2001, Kiel and Williams 2007) found that: (1) in many cases, discovery of contamination caused an initial decline in nearby residential property values; and (2) activities undertaken by the Superfund program had varying effects on property values. In general, there is a lack of consideration of the series of events associated with hazardous waste contamination and cleanup in the available literature, and evidence linking price effects and Superfund is mixed.

The lack of comprehensive consideration of the series of events associated with hazardous waste contamination and cleanup in a way that provides an understanding of the timing and causation of property price effects limits the usefulness of hedonic pricing studies of property for drawing conclusions about the benefits of the Superfund program. The existing property value studies of the Superfund program provide insights into the effects of NPL sites on property values, but due

to the lack of consideration of individual events and timelines, are inadequate for an overall evaluation of the Superfund program. To assist analysts seeking to assess land cleanup and reuse activities, EPA is currently drafting the *Handbook on the Benefits, Costs, and Impacts of Land Cleanup and Reuse* which will include guidance on hedonic analysis.

I. Introduction

Comparisons of the costs and benefits of government programs are a useful source of information about how to implement, evaluate, or improve programs, especially when such comparisons are augmented by considerations of uncertainties, equity, and other issues (Arrow et al. 1996; Pindyck 2000; Northridge et al. 2003). Calculating the benefits of such government programs, however, can be challenging. This report evaluates how prior studies of property values near Superfund sites can be used to provide insights into the overall benefits of the Superfund program.

A few efforts to estimate some of Superfund's benefits have been conducted (Thayer et al. 1991; Hamilton and Viscusi 1999a; Chattopadhyay et al. 2005; Greenstone and Gallagher 2008). Many prior studies have attempted to use property value data to evaluate property value effects of specific Superfund sites. Contamination of properties by hazardous substances creates health risks (or perceptions of health risks), which can lower the value of those properties. These risks may also be present on nearby properties if there is a chance that the contamination has spread, whether through ground water or other media. Cleanup of contamination can reduce or eliminate health risks and may therefore, under hedonic valuation theory, reverse the decrease in property values[1]. It is this change, or increase in value, that may reflect the benefits of the Superfund program. There has been no previous systematic evaluation, however, of how well existing studies can be used to estimate the benefits of the Superfund program as a whole.

This report reviews the literature of residential property value studies of the Superfund program and a few closely related studies. Most of these studies rely on the theory of hedonic valuation. The review finds that existing studies allow some limited conclusions about the relationship between contamination and real estate prices. However, these studies rely on data that are loosely linked to specific actions taken at NPL sites and do not consider other non-NPL Superfund activities.

There are no property value studies on the potential value of non-NPL Superfund activities, such as research, removal actions, or natural resource restoration. Each of these sets of activities has costs and benefits (Farrell 2007). For instance, most analysts who have analyzed removal actions have concluded that they do mitigate significant risks (Koshland 1991; Hird 1994; General Accounting Office 1995; Wildavsky 1995; Office of Management and Budget 2003). Hird mentions removal actions prominently in the book "Superfund: the Political Economy of Environmental Risk":

> "Indeed, much of Superfund's success lies with the removal action program, which has removed more than 2,600 immediate threats to health and the environment since 1980 and has reduced substantial risks at many sites at relatively little cost. Thomas Grumbly, former Director of Clean Sites, Inc. and former U.S. Department of Energy Assistant Secretary for Environmental Management, stated that EPA's removal program 'has probably eliminated most of the *immediate* health risks posed by abandoned hazardous waste sites'" (Hird 1994, pp. 29-30, 112).

[1] Hedonic valuation theory is described in Section II, Evaluating the Superfund Program Using Hedonic Valuation of this study.

Such conclusions remain qualitative; the data necessary to quantify the health risks reduced or avoided due to removal actions are not currently collected, largely because removal actions are predominantly responses to emergencies or other events needing immediate attention (Farrell 2007).

This report has four sections, including this introduction. The second section presents hedonic valuation theory and its application to the Superfund program. The second section also includes a discussion of the sequence of events that occur at NPL sites, in order to illustrate the limitations of applying hedonic valuation theory to evaluate the Superfund program. The third section reviews existing economic literature on the effect of hazardous waste sites (including NPL sites) on residential property values. The fourth and final section presents the report's conclusions and summary.

Regulatory Background

In the 1970s, growing public awareness about the Love Canal neighborhood in New York and other sites contaminated with hazardous substances sparked a national controversy (Wildavsky 1995). The ensuing debate over how best to deal with a legacy of poorly managed hazardous wastes led to the creation of the Superfund program under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) in 1986. Together, these and other related laws established a federal program for preventing, responding to, and mitigating releases of hazardous substances that might threaten human health and the environment (Farrell 2007).

Under CERCLA, the U.S. Environmental Protection Agency (EPA) may place contaminated sites on the NPL in order to use one of two mechanisms for remediation. The first mechanism uses CERCLA's liability provisions. These provisions enable EPA to sue the responsible parties, to order them to clean up the site, or to recover costs if EPA performs the cleanup. The second mechanism allows EPA to clean up the site when no responsible parties can be found or when identified responsible parties are financially unable to pay for the cleanup.

Contamination of sites by hazardous substances is a persistent and pervasive problem. Over the last 28 years, the Superfund program has responded to thousands of releases (or potential releases) of hazardous substances into the environment and continues to respond to new (or newly discovered) releases every year. Superfund actions have reduced, halted, or prevented the exposure of many people to hazardous substances, and have permanently destroyed, isolated, or reduced the toxicity of thousands of tons of these substances (General Accounting Office 2003; Sheldrake and Stifelman 2003).

Superfund Program Activities

The Superfund program encompasses many different activities including: removal actions and remedial response activities; community involvement; enforcement; research and development; training; and natural resource restoration (Farrell 2007). The federal government implements many of these activities, but states and private firms also play key roles in implementation. CERCLA and SARA are the authority for all federal actions. The federal government also

provides significant budgetary support for state environmental programs. By the end of Fiscal Year 2004, the states had evaluated over 44,000 sites for the possibility of hazardous substance contamination. Of these sites, 3% were placed on the NPL. Also by fiscal year 2004, EPA had conducted over 9,400 removal actions, while states had completed over 30,000 removal and remedial actions at sites throughout the country. The six activities associated with the Superfund program are described in greater detail below.

Responses are divided into two types, removal actions and remedial actions, which are largely differentiated based on extent and regulatory process. Removal actions are responses designed to address imminent human health and ecological risks due to uncontrolled releases of hazardous substances. Statutory authority for emergency, time critical, and non-time critical removal actions provides for rapid response when risks are urgent. Remedial actions are responses to the amount, toxicity, and mobility of hazardous substances to reduce long-term human health and ecological risks. Both removal and remedial actions are often accompanied by searches for potentially responsible parties (PRPs) who are obligated to pay for the activities. There is evidence that remedial actions create benefits by reducing health risks. One example of this is Lybarger et al. (1998), which estimated the incidence of birth defects at Superfund sites.

Second, the Superfund program has an active community involvement effort that helps the public understand the remedial process at all NPL sites and for some removal actions and provides the EPA with feedback and input related to site activities. The Technical Assistance Grant program and the Technical Assistance Services for Communities (TASC) contract provide educational and technical assistance to communities affected by hazardous waste sites regulated by the Superfund program. Both provide independent experts to explain hazardous waste issues at contaminated sites and to interpret EPA's plans for cleaning up that waste. Technical assistance efforts help individuals, families, and communities understand the contamination and remedial process at sites and participate in Agency decisions about those sites (Office of Superfund Remediation and Technology Innovation, 2008).

Enforcement provides a mechanism to ensure that clean up costs are funded by PRPs. Enforcement authority derives from CERCLA's stringent liability and enforcement provisions. Liability and enforcement provisions also serve as a support to state response programs and encourage private firms to respond to releases on their own. CERCLA's joint and several liability provisions permit EPA to either compel a PRP to abate an endangerment to public health, welfare, or the environment, or to recover the costs of an EPA-funded response. Often, enforcement actions lead to settlement agreements in which PRPs agree to perform or pay for much or all of the remediation work. About two-thirds of responses are led by PRPs through such settlement agreements. Occasionally, EPA must pursue litigation, such as in cases where EPA has paid for response actions and needs to recover costs. In many cases, enforcement activities can ensure that the parties responsible for a site's contamination pay for the costs of cleanup.

Research and development (R&D) address the problem of uncontrolled releases of hazardous substances in a variety of direct and indirect ways. R&D is supported by EPA's Office of Research and Development (ORD) and Environmental Response Team; the Agency for Toxic Substances and Disease Registry (ATSDR); and the National Institutes of Environmental Health

Sciences, through the Superfund Basic Research Program (SBRP). These efforts include both basic and applied research (Anderson et al. 2002; Ozonoff 2003). .

ORD, ATSDR, SBRP, and other Superfund-related organizations engage in training for a variety of groups, including first responders (e.g., firefighters), first receivers (e.g., emergency room staff), and scientists (McCunney 1996; Zeitz et al. 2000). While there are limitations in understanding hazardous material risks and in the methods and technologies for managing releases, these research and training efforts have improved scientific knowledge and practical capabilities since 1980. Training also provides professionals with the competencies needed to identify and respond safely to uncontrolled releases of hazardous substances.

The Superfund program engages in natural resource restoration, which restores ecological functions that have been damaged or destroyed by uncontrolled releases of hazardous materials (Morey et al. 2002; Breffle and Rowe 2002; Mathews et al. 2002). Natural resource restoration has become an increasingly important activity taken under Superfund authority in the last decade. Natural resource restoration activities are not directly undertaken by EPA, rather by organizations that act as public trustees, including several federal departments (e.g., the Department of Commerce and the Department of the Interior), states, and tribes. Uncontrolled releases of hazardous substances can significantly injure ecological systems and CERCLA authorizes federal and state agencies to mitigate these effects through natural resource restoration.

II. Evaluating the Superfund Program Using Hedonic Valuation

Considerable research has been conducted on the relationship between property values and hazardous substance contamination (e.g., Farber 1998; Boyle and Kiel 2001; Braden et al. 2004; Ihlanfeldt and Taylor 2004). Many different studies of specific NPL sites have been conducted with the *hedonic price method* (HPM), which uses information from real estate markets (Rosen 1974; Bartik 1988; Boyle and Kiel 2001). In this approach, differences in home prices are assumed to derive from differences in the characteristics that comprise the homes, including the number of bedrooms, square footage, and any risks and disamenities associated with living or working on or close to contaminated properties.

This section discusses the theory of hedonic valuation and the evaluation of Superfund program benefits using hedonic valuation methods. In order to understand how changes in property values can illuminate the benefits of the Superfund program, it is necessary to understand the sequence of events that occur at contaminated properties, and how the Superfund program affects this sequence of events. This section also describes scenarios for events that would occur with and without the existence of the Superfund program.

Hedonic Valuation Theory and its Application to the Superfund Program

In analyzing the benefits of the Superfund program, there are no markets for any of the activities undertaken by the Superfund program, and therefore no observable prices to indicate their value. To account for this, economists have developed other methods for estimating values for these types of effects. To evaluate goods that are not traded in markets, economists either rely on data from actual markets for related goods (revealed preference methods) or on interviews and questionnaires about untraded goods (stated preference methods). The HPM is a revealed preference methodology that has been applied to sites contaminated with hazardous substances.

The economic benefits of public policies like Superfund can be described using measures of individual satisfaction or well-being, referred to as measures of welfare or utility. Economic theory assumes that individuals can maintain the same level of utility while trading different "bundles" of goods, services, and money. The willingness to trade off compensation for goods or services can be measured either as *willingness to pay* (WTP) or as *willingness to accept compensation* (WTA). Economists generally express WTP and WTA in monetary terms. In the case of an environmental policy, WTP is the maximum amount of money that an individual would voluntarily exchange to obtain an improvement in relevant environmental effects. Conversely, WTA is the least amount of money that an individual would accept to forego the improvement.

The theory of hedonic valuation (from which the HPM is derived) begins with the observation that some products (or commodities) can be differentiated by the amounts of various characteristics they embody (Rosen 1974; Freeman 1993). In this theory, consumers value heterogeneous goods (such as houses) based on characteristics that are both intrinsic and external to the items themselves. Characteristics that consumers value may include structural attributes (e.g., number of bedrooms, area and age of house), neighborhood attributes (e.g., population demographics, crime, and school quality), and environmental attributes (e.g., air quality and

proximity to hazardous waste sites). Producers or sellers incur costs that are dependent on the types of commodities they provide (Palmquist 1992; McConnell 1993).[2] In this sense, individuals view housing units as bundles of attributes and derive different levels of utility from different combinations of these attributes. Market prices are set by the interaction of the supply and demand schedules.

When decisions to buy and sell are made, individuals make tradeoffs between money and these attributes. According to hedonic price theory, differences in the prices of heterogeneous goods can be used to estimate the implicit value that people place on the characteristics of those goods. Observation of the buying and selling behaviors of individuals reveals the marginal values of these attributes, which are central to hedonic property value studies.

Hedonic property value studies apply statistical regression methods to data from real estate markets to examine the increments in property values associated with different attributes. Because actual behaviors (e.g., home purchases) are used for data, such revealed preference methods may be less vulnerable to strategic manipulation and study design problems than stated preference methods, which rely on surveys and questionnaires.

Hedonic valuation theory assumes a competitive market in equilibrium and assumes perfect information and zero transaction costs (Palmquist 1992; McConnell 1993). Most applications of property-based price theory to real estate consider only residential properties (Boyle and Kiel 2001).

Superfund responses at NPL sites can lead to two types of benefits. First, response actions can reduce actual exposure (or the likelihood of future exposure) to hazardous substances, which can lead to health benefits. Second, people living near NPL sites may have a better sense of well-being (i.e., "feel better") if the stigma associated with living near once-contaminated sites is eliminated through removal of any fear or uncertainty associated with potential health risks (Dale et al. 1999; Fischhoff 2001; Kasperson et al. 2001).[3]

Specifically, stigma may cause declines in property values that result in shifts in the composition of a neighborhood, including a decreased ratio of homeowners to renters; a decrease in average income of residents; and a decrease in the overall status and political power of residents. This process would only be expected in areas where there was a long lag between when a site was first discovered and eventually cleaned up. An important aspect of stigma is that it may result from changes in a community that remain even after the health risks of contamination are eliminated, such as deterioration in housing stock (Fischhoff 2001; Gregory and Satterfield 2002). There is evidence that such long-term effects have occurred at NPL sites and may be especially problematic when remediation activities are delayed (McCluskey and Rausser 2003a; Messer et al. 2006). There is also evidence that NPL remediations themselves can cause stigma

[2] Heterogeneous goods, such as automobiles and houses, are sold within a single market but can vary in characteristics. They can be contrasted to commodity goods, such as minerals and basic foodstuffs, which are sold in a single market but do not vary significantly in characteristics.

[3] In this context, stigma is attached to an area (or site) after it has been identified as contaminated and therefore dangerous, but stigma actually only occurs if an area that was once identified as acceptable gains a lasting reputation for being blemished or inferior.

(Satterfield et al. 2001). Many of the most recent property-based studies focus on the role of information in changing perceived risk near hazardous waste sites over time (Kiel 1995; McMillen and Thorsnes 2000; Gayer et al. 2002).

Rosen (1974) first modeled the interactions of consumers and producers in markets, and his approach underlies all subsequent studies. He developed the "hedonic price function" or model, P = P(**z**), where P is price and **z** is a vector of product characteristics valued by the consumer and produced by the supplier. For a home, these characteristics might include size, number of bedrooms, and location. Rosen's analysis improved the practice and interpretation of analyses in which the observed prices of differentiated products are regressed on relevant attributes (including environmental amenities) in order to obtain estimates of the contribution of each attribute to the total price (Boyle and Kiel 2001).

An example of a relevant hedonic model is shown in Equation 1 (Kiel and Zabel 2001). In this specification, the price *(P)* for house *i* at time *t* (P_{it}) is a log-linear function of home characteristics (*H*), neighborhood characteristics (*N*), and characteristics of the closest NPL site (*S*). The home and neighborhood characteristics examined by Kiel and Zabel include finished area (square feet), age (date constructed), style (e.g., ranch, split, Cape Cod, colonial), unemployment at the census tract level, and median household income at the census tract level. Most of the data, including price, are specific for each home and come from recorded values in real estate transactions. The function that models the effect of an NPL site, $S(D_i;\theta_t)$, is more sophisticated than most other models in the literature, accounting both for distance (D_i) and for phases in the remedial process (θ_t). Otherwise, this specification is typical of the papers reviewed here, with minor differences such as functional form or the inclusion of different home and neighborhood characteristics (e.g., number of bedrooms, racial makeup).

$$\ln P_{it} = \beta_{0t} + H_{it}\beta_{1t} + N_{it}\beta_{2t} + S(D_i;\theta_t) + u_{it} \qquad \text{(Equation 1)}$$

In a hedonic analysis, the data are the price, the characteristics of each home, neighborhood, and NPL site (i.e., P_{it}, H_{it}, N_{it}, D_i, and θ_t), and the results are the estimates for the parameter values, (including all the β values, u and S).

All of the studies reviewed in this paper, except Greenstone and Gallagher (2008), use a similar approach to evaluate the type of model described by Equation 1, in which home-specific data are derived from records of real estate transactions. Gathering these data is labor intensive, so such studies typically evaluate a small number of NPL sites.

There are significant differences among residential, commercial, and industrial property markets, including market size, relevant amenities, structural economic changes, and differences in financing practices. There are a variety of factors that make it harder to determine the condition-specific (proximity to hazardous waste) effect on commercial and industrial property values than to determine the effect on residential property values. Therefore, most studies that examine the benefits of the Superfund program focus on residential properties.

Sequence of Events at Contaminated Sites

A general sequence of events exists for contaminated sites; each event tends to have different implications for the quantity and quality of the information that is available to the public and the risks presented by a site.

Release

The initiating event is release (or threat of release) of a hazardous substance that creates contamination. Although the existence of the Superfund program may create a disincentive for releasing hazardous waste, it is assumed that if a release occurs, this event occurs regardless of the existence of the Superfund program. Releases can occur over short or long periods of time, as wastes accumulate or chemicals leak from storage facilities. Health and environmental risks may begin immediately after a release or take longer to develop. Risks are present when all of the elements that comprise a completed exposure pathway are present: an environmental medium and transport mechanism; a route of exposure; a point of exposure; and a receptor population.[4] The entity that causes the release, exposed individuals, and the public may be unaware of the release and therefore of any health risks. Releases can lead to risks, but because of insufficient information, these risks may not be reflected in the value of nearby properties.

Discovery

The discovery of the release is the next event. The discovery informs people who own, work on, or live near a site that they are potentially exposed to a hazardous substance. Discoveries of hazardous substance spills or hazardous waste are often made by concerned citizens, first responders (e.g., fire fighters or police), or local officials (Office of Technology Assessment 1989, pp. 10-11; Hird 1994, pp. 14-15, 19). Discovery is almost entirely separate from the Superfund program; many discoveries predate CERCLA, and discovery is not one of the functions of the Superfund program. However, the Superfund program supplies mechanisms for handling discovery information by providing authority and support to the National Response Center. The National Response Center is a 24-hour facility that acts as the single point of contact for all pollution incidents reported in the United States and alerts the appropriate federal On-Scene Coordinator to respond to releases.[5] As a result, the Superfund program improves the quality and availability of information about releases after they are discovered.

"Without-Superfund" and "With-Superfund" Scenarios and Continued Sequence of Events

Once a release of hazardous material has been discovered, property values may decline because consumers prefer not to live or work near places that put them at higher risk to adverse health outcomes. (Thus, the reduction in property values would be a result of the increase in health risks.) In addition, liability to clean up the contamination may be incurred at this time, thus reducing the market value of the contaminated site. However, there may be a long delay – months or years – between the release and its discovery, during which time exposures continue

[4] For a general discussion of this issue, see Williams and Paustenbach (2002).

[5] See www.nrc.uscg.mil/index.htm for more information (accessed January 22, 2008).

without any attendant risk information. In these cases, imperfect information results in real estate prices that may be completely independent of the nearby health risks and therefore do not accurately reflect the risks of contamination during the period between release and discovery.

At this point, it is useful to consider two potential scenarios: a scenario in which there is no regulatory mechanism for dealing with hazardous contaminant releases ("without-Superfund"); and a scenario in which a regulatory mechanism does exist ("with-Superfund"). The without-Superfund sequence of events is similar to that at contaminated sites before the Superfund program was created.

Without-Superfund Scenario

Responses to the events at Love Canal, the Valley of the Drums, and other sites discovered in the late 1970s were uncoordinated and ad hoc, with some of the events becoming crises (Colten and Skinner 1996; Mazur 1998). No specific agency had expertise, authority, or resources to deal effectively with these problems, although disaster management, public health, and environmental protection agencies all played a role in responding to these events. Little is known about residential property values near these sites except that they plunged dramatically. Many of these sites were abandoned and the original owners or occupants who created the contamination disappeared or went bankrupt. These events subsequently gave rise to the creation of CERCLA.

In the hypothetical without-Superfund scenario, only by bringing the polluter to court in a nuisance case could liability for cleanup be assigned. Such cases would typically create uncertainty and take time to resolve. In the meantime, exposure would likely continue, exacerbating human health impacts. If a judgment was won against the polluter, the costs of cleanup might be assigned to the property through a lien, lowering its value by associating acquisition of the property with legal responsibility. However, if the polluter won in court, or if it was not possible to bring the polluter to court, there might be no response action and the exposure would continue. In this case, the value of the contaminated property would likely be reduced due to the costs and risks associated with an ongoing release.

The without-Superfund scenario has several other negative characteristics. Uncertainty would surround the contaminated site. Depending on the wishes of the owner and the capabilities and resources of affected populations, information about the contamination and attendant risks might or might not be gathered and disseminated. In addition, the research and training activities funded by the Superfund program would not exist and may result in fewer technological advances and possibly improper or unsuccessful attempts at cleanup. Further, natural resource restoration would likely not occur without the authority that CERCLA grants to various agencies. Lastly, while it may be feasible, it likely would be less efficient for communities or states to individually create a viable alternative to Superfund; some activities benefit from economies of scale that the federal government can exploit (e.g., R&D and the National Response Center) and others appear to be within the constitutional scope of the federal government (e.g., liability provisions).

With-Superfund Scenario

After the discovery of a release of hazardous contamination in the with-Superfund scenario, as in the without-Superfund scenario, declines in property values associated with increased health risks may occur when information about the discovery of the release is made public. However, it should be noted that in many situations, Superfund improves the quality of information surrounding discovery of a site. It is also possible that the involvement of Superfund may signal that a site will be remediated in a timely and effective manner. Therefore, after Superfund investigates, a community will have more precise information that might suggest contamination at a site is greater or less than originally suspected. Moreover, because the discovery of a potential health risk is not associated with the Superfund program, any uncertainty about such risks is not attributable to the Superfund program but to the release and discovery. As discussed below, the Superfund program tends to reduce uncertainties about the status and prospects of contaminated sites, although it may introduce some uncertainties as well, such as those associated with liability.

In the with-Superfund scenario, these actions would become public through required disclosures because they are performed by public agencies (mostly EPA). This would provide information to both neighbors and participants in real estate markets. This additional information might tend to move real estate prices up or down after the initial effect on prices resulting from the discovery. If little contamination is found, then the corresponding health risk and uncertainty about this fact is eliminated. On the other hand, if a site *is* contaminated, steps will be taken to protect human health and the environment (possibly through emergency or time-critical removal actions, NPL listing followed by remedial actions, or determining that a site is not suitable for NPL listing but is better handled by the state). The effect of the Superfund program will be to directly or indirectly (in cases of state deferral) reduce health risks, as well as resolve the uncertainties associated with the discovery. Regardless, if a site is contaminated, Superfund actions should begin to restore property values to their pre-discovery values. This may not be the case, however, at sites with complex, highly visible or contentious remedies, or time-consuming remedial actions.

In the with-Superfund scenario, a site that requires further cleanup is not automatically placed on the NPL. The site could be cleaned up by the responsible party, possibly as part of a state-supervised Voluntary Cleanup Program, or it could be cleaned up by the state itself. If a site is placed on the NPL, a set of investigations and cleanup procedures would begin. For sites eventually placed on the NPL, the general sequence of events includes:

1. Site discovery
2. Proposal to the NPL
3. Final NPL
4. Remedial investigation/feasibility study
5. Release of the Record of Decision (ROD) in which the remedy is selected
6. Design and construction of the remedial actions
7. Construction completion (when the construction of remedies is completed and the operation and maintenance of the remedy begins)
8. Deletion from the NPL

The with-Superfund scenario is different from the without-Superfund scenario in four major ways. First, the existence of an expert system responsible for handling discoveries of contaminated sites (the National Response Center) would tend to improve the quality and availability of information about the risks posed by releases of hazardous materials. Fast, expert response to immediate health hazards tends to reduce any health risks. In such cases, it would be inappropriate to allow health risks to continue while waiting for investigators, lawyers, and possibly the courts to determine responsibilities. Second, the existence of strong and clear provisions establishing liability may cause the polluter to act differently, potentially reducing the risk (and therefore liability). Third, a series of screening and other investigations would be undertaken to determine what remedial action, if any, might be required. Any remediation would address risks not addressed by removal actions already undertaken. Remedial investigations sometimes discover the need for additional removal actions, which is another way that the with-Superfund scenario results in less risk than the without-Superfund scenario. Fourth, communities would have access to information about contaminated sites and an enhanced ability to understand that information in the with-Superfund scenario.

The sequence of events under this scenario affects real estate prices depending on how the information is interpreted by buyers and sellers in the real estate market. If real estate prices reflected actual health risks correctly (i.e., if perceptions of health risks exactly matched actual health risks), then discovery would cause property values to decline due to the newly discovered risks. Subsequent to this discovery, the Superfund program would generate information about a site and how Superfund could act to reduce health risks.[6] If markets responded to information about contamination and activities to reduce exposure by considering only objective health risks, the decline in the value of real estate would reverse as the risk and the related uncertainties about impacts of the risk are diminished. It should be noted, however, that if the information from a site's investigation phase uncovers information that shows there is more risk then previously thought, there might be a further reduction in property values.

Summary

There are major differences between the with-Superfund and without-Superfund scenarios. In both scenarios, however, it is the release of hazardous material that causes health risks and the subsequent reduction in area property values. In the with-Superfund scenario, the discovery of a release is more likely to be responded to quickly. More information is also generated about the risks of hazardous material contamination, reducing uncertainties. Both short-term and long-term risks are more likely to be reduced, and reduced more quickly, in the with-Superfund scenario.

[6] The generation of information about a site and how to reduce health risks may happen in either scenario, but would likely be slower in the without-Superfund scenario.

III. Literature Review

This section reviews the hedonic valuation studies that evaluate the impact of NPL sites on the property values of residential homes located near the sites. The studies were identified through a literature review, which was conducted using EconLit, Web of Science, and several electronic catalogs, as well as e-mail correspondence with experts to identify gray literature.[7] Studies that could be used to quantitatively measure the benefits of the Superfund program were of primary interest, so studies that provided estimates of the "price effect" of NPL sites on nearby properties were prioritized. To be selected, studies had to be published in peer-reviewed, archival journals that presented original data or substantial re-analyses of data.[8] To avoid over-weighting data from any particular site, a second study that used the same data as an earlier one were generally avoided. McClelland et al. (1990) and Hurd (2002) share some data, but are sufficiently different to avoid the problem of double counting.

This section presents a summary of the literature on hedonic valuation studies of residential home prices for houses near NPL sites. In general, these studies report on the effects that proximity to an NPL site and discovery of contamination have on home prices. Determining the correspondence between possible declines and increases in property values is limited by a variety of factors, including available information. Therefore, care is required when linking changes in home prices to benefits. Overall, this literature review revealed that little is known with certainty about these property value impacts. In general, the data and methods do not distinguish among the different events that take place on NPL sites (discovery, removal action, etc.). In addition, the studies evaluate a small set of potentially unrepresentative sites.

Only twelve studies provided quantitative estimates of the price effect; these studies are presented in Table 1. All price information is adjusted to the year 2000 by the Bureau of Labor Statistics' Consumer Price Index for all goods for all urban consumers per Boyle and Kiel (2001). Some of the studies use only cross-sectional data (those labeled 'C'). With the exceptions of Kiel and Zabel (2001) and Kiel and Williams (2007), many of these studies aggregate data across time, and may or may not be suitable for examining the effect of any specific event, depending on how the aggregation is performed.

The potential role of removal actions that occur at NPL and non-NPL sites on price effects of nearby homes is not discussed in any of the property value studies. Therefore, existing property value studies do not explicitly consider the benefits of removal actions at NPL sites. These studies may still be useful in evaluating remedial actions. However, ignoring removal actions, which are common at NPL sites, may distort property value studies of individual remedial actions as well as ignore the benefits at sites with removal actions that are not on the NPL. For all these reasons, the existing literature of property value studies of the Superfund program is inadequate to draw overall estimates and conclusions regarding the benefits of the overall Superfund program.

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[7] Gray literature is a term used to describe unpublished studies, dissertations, and papers.

[8] Using these criteria, the following studies were excluded: Smith and Desvousges (1986); Kohlhase (1991); Gayer et al. (2000); McMillen and Thorsnes (2000); Gayer and Viscusi (2002); McCluskey and Rausser (2003a, 2003b); and McMillen (2003).

Most of the studies in Table 1 (labeled 'P') use panel data sets that include both longitudinal (time series) and cross-sectional information. These studies examine home sales over several years, grouping sales into different time periods defined by changes in site status or available information. In some longitudinal hedonic studies, data may be collected for the period before a site is proposed for listing on the NPL, while a facility is operating, after a site is listed, and after the remedial action. Longitudinal studies may rely on repeat sales of the same home, which helps to avoid the problem of potentially omitted variables.[9]

All the studies in Table 1 report results from different data sets, although the data used by Hurd (2002) includes data used by McClelland et al. (1990). Most of the policy studies use data from about two thousand houses; McClelland et al. (1990) use an unusually small set (178 homes) and Dale et al. (1999) employ a very large data set (203,353 homes). The maximum distance at which an effect is detected ranges from 0.57 miles to 6.2 miles, with a mean of 3.0 miles. Five studies find an effect at or beyond 2.5 miles and only two studies do not find an effect at all.

All but two of these studies evaluate only a small number of sites that may not be representative of NPL sites. One of the two studies evaluates a majority of NPL sites and uses a different approach (Greenstone and Gallagher 2008). The study uses census tract-level data, which are highly aggregated, decadal, and self-reported, and which can introduce biases of unknown direction and size due to spatial effects and measurement error due to data aggregation. These data problems undermine the study's usefulness as a source of aggregate benefits information on the Superfund program. The second study analyzes data for 57 NPL sites and finds mixed results in terms of expected effects (Kiel and Williams 2007).

Table 2 shows the dates for specific events in this sequence, along with the periods during which property data were collected for each of the sites examined in the studies reviewed. No data are shown for: Thayer et al. (1991) because they are not available; Greenstone and Gallagher (2008) because the study evaluates all sites and uses slightly different data than the information presented in the table; and Keil and Williams (2007) because the study reports on 57 sites and focuses on the effects found during listing on the NPL and is not applicable to the structure of Table 2. Table 2 also contains information on the study by Kohlhase (1991) because of its relevance to the question of the timing of the price effect. However, Kohlhase (1991) does not present price effect values and so is not included in Table 1.

[9] Omitted variables are factors that might influence an analysis but are not included, often due to a lack of available data. Examples include interest rate changes or the installation of central air conditioning.

Table 1. Price Effect Estimates from Hedonic Price Method (HPM) Studies of Homes Near Hazardous Waste Sites

Study	Decline per home (2000$) [a]	Percent effect [b]	Number of sites	Number of homes	Cross-sectional or panel	Time period in years	Maximum distance from site
McClelland et al. 1990	$16,317	7.3%	1	178	C	83-85	NA
Michaels and Smith 1990	$363	None	11	2,182	C	77-81	6.2 mi.
Mendelsohn et al. 1992	$11,804	7.5%	1	1,916	P	69-88	2 mi.
Thayer et al. 1991	Size of effect not reported	Size of effect not reported	16 non-NPL	2,323	C	85-86	4 mi.
Reichert 1997	$9,085	7.1%	1	1,586	P	77-94	2.5 mi.
Dale et al. 1999	$24,912	16%	1	203,353	P	79-95	2 mi.
Kiel and Zabel 2001	Size of effect not reported	Size of effect not reported	2	2,209	P	75-92	2.5 mi.
Gayer et al. 2002	$3,157	3.4%	7	1,883	P	88-93	4 mi.
Hurd 2002	$6,739	3.1%	1	Not given	P	83-85 94-97	3,000 ft.
Chattopadhyay et al. 2005	$34,130	26.6%	3	2,500	C	96-01	~ 12 mi.
Greenstone and Gallagher 2008 [c]	None	None	985	48,147	P	80-00	NA
Kiel and Williams 2007	$15,466[d]	16.26%	18	Not given	P	Report events not years	3 mi.
	Significant increase with distance – size not reported [d]		7	Not given	P	Report events not years	3 mi.

Notes:

a) Being "close" to the site, lowers the property value by the amount reported. Values are based on individual real estate transactions except for Greenstone and Gallagher (2008). See note c.

b) Percent effect is the change in price based on study-specific mean prices, where available.

c) Values are averages of self-reported home prices across census tracts.

d) 18 of 57 sites found that the closer to the site, the lower the property value ($15,466) and 7 sites found the closer to the site, the higher the property value (size of effect not reported).

Table 2. Events and Data Collection for HPM Study Sites

Study	Site Name	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
McClelland et al. 1990 Hurd 2002	Operating Industries					D					P		L	ERS															E		
Michaels and Smith 1990	Industri-Plex					D			P	L			ER		E				S												
	Nyanza Chemical						D		P	L		R		SE	E	E			E												
	Salem Acres						D				P		L		E		E			R	S				C		X				
	W.R. Grace					D			P	L						R				S											
	Wells G&H					D			P	L			E	E	E	R			S												
Kolhase 1991	Brio Refining								D		P	E			R	LS															C
	Crystal Chemical						D		P	LE					E		R	E				S							C		
	Geneva Industries							D		PE	LE		R	S						C											
	Harris (Farley)								DP	L		R	S		CX																
	N. Cavalcade St.										DP		L		R			S													
	Sol Lynn										DP				R	LE		S		C								E			
	S. Cavalcade St.									D	P		L		R							S				C					
Mendelsohn et al. 1992	New Bedford	(Data from 1969)				D			P	E	L	E	E				R	S													
Reichert 1997	Industrial Excess						D				P		L	R	E	RS				E											
Dale 1999	RSR Smelter							D												P		LER					S		E		
Kiel and Zabel 2001	Industriplex					D			P	L			ER		E				S												
	Wells G&H					D			P	L			E	E	E	R			S												
Gayer et al. 2002	Butterworth #2					D			P	L						E	E		R						S		C				
	Chem Central				D				P	L								R			S	C									
	Folkertsma Refuse							D					P			L		R		S	C		X								
	H. Brown Co.						D					P	L						ER							S	C				
	Kentwood	(Data from 1971)						P	L								R			S	C										
	Organic Chemicals					D			P	L								R			S								C		
	Spartan Chemical					D			P	L										R						S					
Chattopadhyay et al. 2005	Johns-Manville								DP	L	E			R	S			C										E			
	Outboard Marine						D		P	L	R					R	S												E		
	Yeoman Creek	(Discovery 1970)													P	L	S				E	E	R				E				

Legend:

Events: D-Discovery; P-Proposed to NPL; L-Final on NPL; E-Removal Action; R-ROD; S-Start of Remedial Action; C-Construction Complete; X-Deleted

Colors: Different shades indicate how panel data were divided longitudinally. The grid squares in the table are shaded to show the years for which data were gathered for each study. If the study is cross-sectional, different periods are shown with different shades. For ease of use, only two shades are used, even if more than two periods were defined in the study, which was the case for two papers (Dale et al. 1999; Kiel and Zabel 2001).

For each of the studies in Table 1, three issues were investigated: (1) the magnitude of the change in home price; (2) available evidence for the causes of price declines; and (3) available evidence regarding any reversal (or rebound) in the change in home prices. The pattern of price changes and the events that cause them are crucial to determining what can be counted as a benefit of the Superfund program.

Estimates of a Decline in Home Prices

This subsection evaluates the significance of the price effect and focuses on identifying how much the values of residential properties change due to the proximity of NPL sites.

Most of the studies do not consider the issue of causality, or make assumptions about which activities cause particular price changes, because examining these questions are not critical to the studies they are conducting. For most studies, the questions of causality necessary to investigate the benefits of Superfund cannot be tested. A few of the studies claim to find evidence of an "announcement effect," which is a change in property values based on the release of new information about the risks associated with a particular site (e.g., Kohlhase 1991). However, they generally do *not* have sufficient evidence to support this claim because they do not control for different events (e.g., discovery, listing, removal actions, etc.) at the sites evaluated. In many cases, the purpose of the studies is not to assess the benefits of the Superfund program, and the studies are asking questions that do not require controlling for different events. However, to estimate the benefits of Superfund, it is crucial to distinguish between discovery of contamination and the listing of a site on the NPL in order to isolate the effects and show causality. While Kiel and Williams (2007) successfully control for different events, their results are mixed in terms of price effect magnitude and direction.

Kohlhase (1991) finds no housing price differences in 1976 and 1980, which Table 2 shows is before discovery for all but one of the seven sites examined. Because the sites had not been discovered (except for the one), there is no reason to expect that they would have any effect on housing prices. Kohlhase finds significant declines in property values in 1985. However, this year comes after all seven sites had been discovered and proposed to the NPL and after three sites had been listed on the NPL. Therefore, these data cannot be used to identify which event – discovery, proposal, or listing – caused the declines. Some combination of these events most likely caused the decline, but because discovery is not associated with the Superfund program, these data cannot be used to evaluate the Superfund program. Further, for six of the seven sites, the 1985 data will reflect *both* discovery and proposed placement on the NPL. These data will also reflect final listing on the NPL for two sites and a total of four removals at three sites. This aggregation across time means that further analysis is unable to establish correlation between specific events in the sequence that occur at sites with hazardous contamination.

McClelland et al. (1990) and Hurd et al. (2002) examine the Operating Industries Landfill in Monterey Park, California and find a negative price effect in 1983-85, several years after discovery but before the site was listed on the NPL (1986). The site was proposed for listing on the NPL in the middle of this period. Again, these data do not distinguish between events that are associated or not associated with the Superfund program.

Michaels and Smith (1990) find a small reduction in home prices at five NPL sites using data from 1977-81, a period that covers both before and after discovery, but before any of these sites are proposed to the NPL (1982 or 1984). One possible reason for the very low values reported by Michaels and Smith (1990) is that most of their data predate discovery. The reduction might have been larger if more of their data points were taken after discovery.

Mendelsohn et al. (1992) find evidence for the New Bedford site that a negative price effect began in 1981, after some state and federal activities related to the discovery of hazardous waste, but before the site was proposed to (in 1982), or listed on (in 1983), the NPL. This suggests the decline in home prices did not accompany placement on the NPL, but is related to some discovery activities.

Kiel and Zabel (2001) find that houses near what later became NPL sites near Woburn, Massachusetts suffered no negative price effect during the mid-1970s while the sites' facilities were operating. After contamination was discovered and site operations were closed down, a negative price effect quickly developed. This occurred before the site was proposed to the NPL in 1982. A lengthy, high-profile lawsuit took place over the course of the next several years, during which these sites became very widely known[10]. The results from Kiel and Zabel (2001) suggest that the price effect fluctuated after discovery, seeming to rise with major events that might draw attention to the site (e.g., release of the site's ROD and the start of remedial action).

Reichert (1997) examines 17 years of data for the Industrial Excess Landfill site and finds little evidence of a price effect from discovery (1980) through proposal (1984) and listing (1986). The price effect in this study appeared during and after 1987, when the site's ROD was released. These results contradict much of the rest of the literature. It is unclear why, although prior community knowledge of the existence of the landfill may explain this result.

Dale et al. (1999) find that the RSR lead smelter site, while operating in the late 1970s before CERCLA and the NPL were established, had a negative effect on the prices of nearby homes. This site has a complex history and the nearby housing market may have received confusing information about potential health risks. Most of the study period for Dale et al. (1999) and much of the response action occurred before the site was proposed to the NPL. The site was first the subject of municipal and state lawsuits and then response actions. A Texas judge declared that the site was cleaned up and the negative price effect began to reverse. However, EPA subsequently discovered new problems at the site and changed the applicable health standard. Thus, the proposal to list this site on the NPL (1993) came after the site had previously been declared cleaned up. In this case, public perception and confusion regarding the status of the site may have led to a return of the negative price effect at the time of listing. McCluskey and Rausser (2003b) evaluate the same site, but use a somewhat different data set and technique (repeat sales data) and also find that proximity to the site reduces appreciation in home prices (not prices, per se) in 1979 and 1980, and that the effect varies after that period. Moreover, McCluskey and Rausser (2003b) interpret their results to indicate that housing markets can take a significant period to adjust to new equilibrium conditions following the addition of new

[10] The Wells G&H site was later the subject of the popular book and movie, *A Civil Action*.

information. Subsequent research by McCluskey and Rausser (2003a), using data similar to Dale (1999), suggests a similar conclusion.

The analysis by Greenstone and Gallagher (2008) differs sharply from the other studies listed in Table 1, both in the method and data that are used. The researchers employ an approach that takes advantage of the fact that when the NPL was created in 1983, 690 sites were evaluated but only 400 sites were placed on the NPL. By comparing home prices in census tracts that had sites that were above the NPL listing threshold with home prices in census tracts that had sites that were below the threshold (labeled a "quasi-experiment"), the researchers apply a HPM method that has elements of both cross-sectional and panel data approaches.

However, while they assemble a significant amount of data, evaluating over two-thirds of all NPL sites, these data are averages of self-reported, census tract-level information on housing prices, housing characteristics, and neighborhood demographics. Census tract boundaries are drawn so that they contain approximately 4,000 people and change over time. In the 2000 Census, tracts containing an NPL site had a mean area of 74 square miles and median area of 10.5 square miles. Census data are also available only once every ten years, when a census is taken. In contrast, other HPM studies use actual sale prices for specific homes on specific dates.

Greenstone and Gallagher conduct three analyses. First, they analyze only census tracts that contain NPL sites. This approach assumes that averages of census tract data reliably measure any effect of an NPL site on the prices of nearby homes. However, if an NPL site is near the edge or corner of a census tract, this assumption may not hold and any effect of the NPL site on home prices affects several different census tracts in addition to the census tract within which the site is located. For example, an evaluation of eight NPL sites in Grand Rapids, Michigan (see Gayer et al. 2002) indicates that five of these sites are on census tract borders or corners, and located closer to more homes in other census tracts than the tract they occupy. Second, Greenstone and Gallagher also analyze these data by including the tracts that share a border with those that contain the NPL site, but exclude the tract that contains the site. The third way Greenstone and Gallagher use these data is to develop population-weighted averages of the average census data for all census tracts within two- and three mile- radii from the site.

For some of the sites in Grand Rapids analyzed by Gayer et al. (2002), this approach means that some homes located more than five miles from a site are counted like those located near to the site, while other homes less than one mile from the site would be excluded from consideration. These efforts do not sufficiently resolve the issues of the once-per-decade Census observation. The timing of the Census data tends to obscure the differences in the effect of the discovery of contamination and Superfund responses. These obscured differences are necessary to fully answer the questions of the current study regarding the overall benefits of the Superfund program.

While Greenstone and Gallagher (2008) look at a larger number of sites than the other studies and assemble a large amount of data, the issues related to using census tract average values likely obscure any effect due to Superfund responses. As a result, Greenstone and Gallagher's (2008) study results may not be applicable to the evaluation of NPL site cleanups or the Superfund program more generally.

Unique among the studies in Table 1, Gayer et al. (2002) use no data prior to discovery; for all but one of the seven sites examined, the sites had been listed for several years (mean 4.5 years). They hypothesize that potential home buyers incorporate new site-specific information from the media into their decision-making, and test this hypothesis by evaluating changes over time in the prices of homes near NPL sites in Grand Rapids, Michigan. They gathered data on media reports about the sites over several years as various investigations and cleanup activities were conducted at the sites. Gayer et al. find support for their hypothesis in a reversal of the negative price effect over the period studied. However, their study began in 1988, well after all but one of the sites had been listed. Because Gayer et al. do not report what information became available when each site was discovered, proposed to the NPL, or listed on the NPL, it is not possible to tell if their analysis captures the full magnitude of any price effect. This has no bearing on Gayer et al.'s conclusions, but it makes their data problematic to apply in this context because they may not capture the total price effect. Capturing only the partial effect may explain why Gayer et al. report the second lowest values for the negative price effect of the studies reviewed.

The recent study by Kiel and Williams (2007) finds, as expected, that in some locations property values decline as they get closer to an NPL site, however, in other locations property values increase. Their hedonic analysis on 57 NPL sites finds that at listing and within three miles of a site: 18 sites had a clear property value decline with distance (the closer to the site, the lower the property value); 32 sites did not have a significant effect; and seven sites had a property value increase (the closer to the site, the higher the property value). Kiel and Williams' (2007) attempts to investigate the reasons for the mixed results uncover that "the larger the site, the more likely it is to have a negative influence on local sales prices." They also find that the reason for the unexpected positive effect on property values may be related to site characteristics and whether or not immediate proximity to the site is an attraction due to employment opportunities.

Kiel and Williams focus their analysis on significant findings related to the event of listing on the NPL. Their analysis of the effects of "listing" raises questions regarding the effect of timing on how property values change in relation to various events at sites. Thirty-three of the 57 sites investigated had a significant negative effect on property values at some point in the sites' history. Kiel and Williams' (2007) approach may provide a method to look more in-depth at individual sites and what is happening at the sites across a variety of events, when the necessary data can be obtained. It also provides evidence that it may be necessary to consider the individual benefit of remediating each site rather than determining a standard price effect that can be applied to all NPL sites when estimating the benefits of Superfund.

Ten of the twelve studies reviewed find that proximity to NPL sites lowers the value of nearby residential properties. The first exception is the Greenstone and Gallagher (2008) study, which finds that NPL cleanups are associated with reasonably small changes in residential real estate prices and rental rates. These changes are statistically indistinguishable from zero. Kiel and Williams (2007) provide that some NPL sites have the expected outcomes, with property values around hazardous waste sites showing reductions after discovery. However, the second exception is that Kiel and Williams (2007) found some sites that had either no significant impact or, in some cases, a positive impact on local property values.

None of the studies reviewed have data adequate to evaluate the question of causality for the price effects evaluated. This lack of data is due in part to the variety of questions being asked in those studies. These studies are not specifically looking to answer the question: What are the benefits of the Superfund program? In addition, the lack of data in these studies is often reflective of the general lack of relevant data. Kiel and Williams' (2007) mixed results provide further indication that it is difficult and possibly inappropriate to extrapolate the findings of the existing studies to conclusions about the overall benefits of the Superfund program.

Although much of the HPM literature finds decreases in property values around the time of discovery, a site's proposed addition to the NPL, and a site's listing on the NPL, the evidence illustrates that the effects are often site-specific and that no single effect or magnitude can be applied across all NPL sites. The existing literature suggests that further research and investigation may provide for greater understanding of how site characteristics and the timing of events play parts in the direction and magnitude of property value effects. An ideal study for comprehensively estimating the impacts of Superfund on residential property values would need to look at each site individually. The study could collect the necessary data to look at every NPL site using an approach similar to Kiel and Williams' (2007) while also exploring more of the impacts surrounding various events in the sites' history.

Estimates of Price Decline Reversals

The literature search identified nine studies that looked for possible reversals in price declines of homes near NPL sites. The studies provide mixed results. One category of studies shows no reversal but does not have data for the periods during which a reversal might occur. Another category of studies shows no reversal but evaluates sites with unusual and complex site histories. A third category tends to find a reversal, and it is based on relatively typical site histories and having data during the period a reversal might occur. The following discussion examines these three categories of studies in more detail.

Two studies do not use data sets that cover events that might be expected to reverse the negative price effect. First, McClelland (1990) finds no price decline reversal, using data that were gathered before listing. However, Hurd (2002) compared McClelland's data from before listing to data after listing, RODs, and the start of the remedial actions and finds a significant reversal of the negative price effect. Second, Kohlhase (1991) does not find a rebound using data that include the listing of only three of seven sites and the publication of a ROD at only one site.

The four studies that found no evidence of a reversal of the negative price effect, or a significantly delayed effect, evaluated only two sites, both with long, complex, highly visible and contentious histories. These sites are heavily stigmatized, which would tend to slow or prevent the reversal of the price effect (Gregory et al. 1995; Kasperson et al. 2001). Kiel and Zabel (2001) evaluate data that cover the period from before discovery through the beginning of remedial action, but show no consistent reversal. However, this study evaluates the atypical Wells G&H and Industri-Plex sites in Woburn, Massachusetts. The site evaluated by Dale et al. (1999) and McCluskey and Rausser (2003a, 2003b) was the RSR Smelter site, which had a complex and atypical history. This site was declared clean by a Texas state court, but EPA later

found it to be contaminated, leading to further response actions and listing on the NPL. This reversal in status appears to fit the critical requirement to create stigma: a violation of a standard and a discrediting nature of the consequences of that violation (Gregory et al. 1995). In this case, the violated standards include the health standards at the site as well as the standards associated with the scientific and judicial processes used by the Texas court.

McCluskey and Rausser (2003b) show theoretically how stigma can affect markets and find evidence of such an effect, but within a relatively limited distance (1.2 miles) of a site. The researchers conclude that information is more important to housing prices than response actions, but they differ as to whether or where a reversal occurred and whether stigma was involved. The same is true of a more recent study that also looked at the Industri-Plex site, as well as three other sites with long, contentious histories, and found little or only partial reversal of the negative price effect (Schulze et al. 2004).

The two studies that examined more typical NPL sites and included data from appropriate time periods find clear evidence of reversal of the negative price effect between listing and RODs. McMillen and Thorsnes (2000) evaluate home prices near a smelter in Tacoma, Washington, including data that stretch from before discovery until well after remedial action had begun. They find that at about the time the site was listed, the negative price effect began to disappear. Further, they find this location subsequently gained an additional value over time after the smelter closed and the remedial action had proceeded. Their findings suggest that there can be both speedy and long-term reversals from the negative price effect that begins after listing. Gayer et al. (2002) evaluate seven sites in Grand Rapids, Michigan and find evidence of reversal occurring throughout the period they examined. Their study period begins after the seven sites had been listed, included the announcement of the RODs, but did not include the start of remedial actions. They find that the release of the Remedial Investigation / Feasibility Study (RI/FS) (which occurs before the ROD in the Superfund pipeline of activities) is a key event in providing information to housing markets, initiating the reversal of the negative price effect.

Overall, this literature provides some evidence that some homes near NPL sites begin to experience a reversal of the decline in price associated with site proximity after the site is listed and before the remedial action is complete, with the possible exception of sites with unique and publicly contentious histories.

IV. Conclusions and Summary

Following are the limited conclusions that emerge from the current study:

- Many studies find that NPL sites have an impact on surrounding residential property values, but the impacts found vary in magnitude and direction.
- Information on timing and attribution of price effects is unclear and not the question most of the existing studies investigated.
- In cases where homes near an NPL site experience a decline in price associated with site proximity, there is some evidence that there may be a reversal of the decline after the site is listed and before the remedial action is complete.
- The existing literature does not provide enough information to apply the results to estimating the benefits of the Superfund program as a whole, nor as a comprehensive estimate of the benefits of the NPL.

Although much of the HPM literature finds decreases in property values around the time of a site's discovery, proposed addition to the NPL, and listing on the NPL, the evidence illustrates that the effects are often site-specific and that no single effect or magnitude can be applied across all NPL sites. In the case of Kiel and Williams (2007), they not only find decreases, but also find increases in property values around Superfund sites. The existing literature suggests that further research and investigation may provide greater understanding of how site characteristics and the timing of events play parts in the direction and magnitude of property value effects.

The amount and direction of the change in price of properties near NPL sites that is attributable to the Superfund program is not clear. In some cases it is assumed that listing a site on the NPL causes an "announcement effect" and reduces the value of the property, while there is evidence that in other cases this may increase the value of the property. Studies that do have adequate data to distinguish between discovery and listing effects provide evidence that sites cannot be generalized; some have price declines, while others result in price increases.

The evidence regarding how Superfund response actions affect a site after NPL listing is also limited and somewhat mixed. Again, some studies that evaluated this issue rely on poorly-resolved data that limit their ability to detect such an effect (e.g., Kohlhase 1991), while other studies find that information, response actions, or both tend to reverse the price decline (e.g., McMillen and Thorsnes 2000; Gayer and Viscusi 2002; Hurd 2002). However, other studies find that there is no reversal or that the reversal is only partial (e.g., Kiel and Zabel 2001; McCluskey and Rausser 2003a; Schulze et al. 2004).

Taken as a whole, review of the residential property value literature related to the Superfund program indicates that contamination may tend to decrease the value of nearby residential properties. However, in some cases site and community characteristics may result in an increase in the value of nearby properties. Overall, the magnitude and direction of the price effect on surrounding home prices appears to vary significantly with individual sites. In cases where price declines are seen, remedial actions may reverse this decline at some sites. If the cleanup of a site is delayed for a long period, a more permanent decrease in value may occur. Studies of non-Superfund sites with hazardous contamination indicate similar declines in property values,

supporting the view that the risks associated with contamination may indeed depress property values.

Most property value studies of the Superfund program are limited because they cover time periods associated with multiple events that are likely to affect property values, some of which are related to the Superfund program and some of which are not. In addition, some studies use data with relatively poor geographic resolution (e.g., Greenstone and Gallagher 2008). For these reasons, although they provide useful information about the general relationship between hazardous substance contamination and property values, these studies may not be suitable for evaluation of the Superfund program.

A range of Superfund program activities can contribute to site cleanup and the reduction of health risks. However, economic studies of the Superfund program have only examined NPL sites and focused on remedial actions. Thus, the removal actions and other parts of the program (including R&D, community involvement, enforcement, training, and natural resource restoration) that may reduce risks at sites or reduce the number, types, or sizes of releases are not studied by the HPM literature. Thus, economic studies of Superfund sites have not made an effort to capture the full range of benefits generated by the program.

In general, the lack of comprehensive consideration of the series of events associated with hazardous waste contamination and cleanup in a way that provides an understanding of the timing and causation of property price effects strongly limits the usefulness of hedonic pricing studies of property for drawing conclusions about the benefits of the Superfund program. The existing property value studies of the Superfund program provide insights into the effects of NPL sites on property values but are inadequate for an overall evaluation of the Superfund program.

Future studies that expand on site specific data and methods that investigate property values based on site events and site characteristics may improve an understanding of the effects of Superfund on property values and provide further understanding regarding the benefits of Superfund.

References

Anderson, B., C. Thompson, and W. A. Suk (2002) The Superfund Basic Research Program - Making a Difference: Past, Present, and Future. *International Journal of Hygiene and Environmental Health* 205(1-2): 137-141.

Arrow, K. J., M. L. Cropper, G. C. Eads, R.W. Hahn, L.B. Lave, R.G. Noll, P. R. Portney, M. Russell, R. Schmalensee, V. K. Smith, and R.N. Stavins (1996) Is There a Role for Benefit-Cost Analysis in Environmental, Health, and Safety Regulation? *Science* 272(5259): 221-222.

Bartik, T. J. (1988) Measuring the Benefits of Amenity Improvements in Hedonic Price Models. *Land Economics* 64(2): 172-183.

Billets, S. and A. Dindal (2007) History and Accomplishments of the U.S. Environmental Protection Agency's Superfund Innovative Technology Evaluation (SITE) Monitoring and Measurement Technology (MMT) Program. *Journal of Testing and Evaluation* 35(5): 486-495.

Boyle, M. A. and K. A. Kiel (2001) A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities. *Journal of Real Estate Literature* 9(2): 117-144.

Braden, J. B., A. A. Patunru, S. Chattopadhyay, and N. Mays (2004) Contaminant Cleanup in the Waukegan Harbor Area of Concern: Homeowner Attitudes and Economic Benefits. *Journal of Great Lakes Research* 30(4): 474-491.

Breffle, W. S. and R. D. Rowe (2002) Comparing Choice Question Formats for Evaluating Natural Resource Tradeoffs. *Land Economics* 78(2): 298-314.

Chang, D. P. Y. (1998) A Case Study in Innovative Outreach - Combining Training, Research, and Technology Transfer to Address Real-World Problems. *Environmental Health Perspectives* 106: 1065-1067.

Chattopadhyay, S., J. B. Braden, and A. Patunru (2005) Benefits of Hazardous Waste Cleanup: New Evidence from Survey- and Market-based Property Value Approaches. *Contemporary Economic Policy* 23(3): 357-375.

Colten, C. E. and P. N. Skinner (1996) *The Road To Love Canal: Managing Industrial Waste before EPA*. Austin, University of Texas Press.

Dale, L., J. C. Murdoch, M. A. Thayer, and P. A. Waddell (1999) Do Property Values Rebound from Environmental Stigmas? Evidence from Dallas. *Land Economics* 75(2): 311-326.

EPA Science Advisory Board (1990) Review of the Superfund Innovative Technology Evaluation (SITE) Program. Washington, DC, U.S. EPA.

Farber, S. (1998) Undesirable Facilities and Property Values: A Summary of Empirical Studies. *Ecological Economics* 24(1): 1-14.

Farrell, A. E. (2007) Overview of the Superfund Program. *Reclaiming the Land: Rethinking Superfund Institutions, Methods and Practices*. G. Macey and J. Z. Cannon, Springer: 25-47.

Fischhoff, B. (2001) Defining Stigma. *Risk, Media, and Stigma*. J. Flynn, P. Slovic and H. Kunreuther. Sterling, VA, Earthscan Publishers: 361-368.

Freeman, A. M. (1993) *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington, DC, Resources for the Future.

Gayer, T., J. T. Hamilton, and W. K. Viscusi (2000) Private Values of Risk Tradeoffs at Superfund Sites: Housing Market Evidence on Learning About Risk. *Review of Economics and Statistics* 82(3): 439-451.

Gayer, T., J. T. Hamilton, and W. K. Viscusi (2002) The Market Value of Reducing Cancer Risk: Hedonic Housing Prices with Changing Information. *Southern Economic Journal* 69(2): 266-289.

Gayer, T. and W. K. Viscusi (2002) Housing Price Responses to Newspaper Publicity of Hazardous Waste Sites. *Resource & Energy Economics* 24(1): 33-51.

General Accounting Office (1995) Superfund: Information on Current Health Risks. Washington, DC, GAO/RCED-95-205: 12.

General Accounting Office (2003) Capitol Hill Anthrax Incident: EPA's Cleanup was Successful. Washington, DC, GAO-03-686: 41.

Greenstone, M. and J. Gallagher (2008) Does Hazardous Waste Matter? Evidence from the Housing Market and the Superfund Program. *The Quarterly Journal of Economics* 123(3): 951-1003.

Gregory, R., J. Flynn, and P. Slovic (1995) Technological Stigma. *American Scientist* 83(3): 220-3.

Gregory, R. S. and T. A. Satterfield (2002) Beyond Perception: The Experience of Risk and Stigma in Community Contexts. *Risk Analysis* 22(2): 347-358.

Hamilton, J. T. and W. K. Viscusi (1999a) How Costly is "Clean"? An Analysis of the Benefits and Costs of Superfund Site Remediations. *Journal of Policy Analysis and Management* 18(1): 2-27.

Hamilton, J. T. and W. K. Viscusi (1999b) Calculating Risks? The Spatial and Political Dimensions of Hazardous Waste Policy. *Regulation of Economic Activity*. Edited by N. L. Rose and R. Schmalensee. Cambridge, MA: MIT Press.

Hird, J. A. (1994) *Superfund: the Political Economy of Environmental Risk*. Baltimore, Johns Hopkins University Press.

Hurd, B. H. (2002) Valuing Superfund Site Cleanup: Evidence of Recovering Stigmatized Property Values. *The Appraisal Journal* 70(4): 426-437.

Ihlanfeldt, K. R. and L. O. Taylor (2004) Externality Effects of Small-scale Hazardous Waste Sites: Evidence from Urban Commercial Property Markets. *Journal of Environmental Economics and Management* 47: 117-139.

Kasperson, R. E., N. Jhaveri, and J. X. Kasperso (2001) Stigma and the Social Amplification of Risk. *Risk, Media, and Stigma.* J. Flynn, P. Slovic and H. Kunreuther. Sterling, VA, Earthscan Publishers: 9-27.

Kiel, K. and M. Williams (2007) The Impact of Superfund Sites on Local Property Values: Are All Sites the Same? *Journal of Urban Economics* 61(2007): 170-192.

Kiel, K. and J. Zabel (2001) Estimating the Economic Benefits of Cleaning up Superfund sites: The Case of Woburn, Massachusetts. *Journal of Real Estate Finance and Economics* 22(2-3): 163-184.

Kiel, K. A. (1995) Measuring the Impact of the Discovery and Cleaning of Identified Hazardous-Waste Sites on House Values. *Land Economics* 71(4): 428-435.

Kohlhase, J. E. (1991) The Impact of Toxic-Waste Sites on Housing Values. *Journal of Urban Economics* 30(1): 1-26.

Koshland, D. E. (1991) Toxic Chemicals and Toxic Laws. *Science* 253(5023): 949-949.

Lybarger, J. A., R. Lee, D. P. Vogt, R. M. Perhac, R. F. Spengler, and D. R. Brown (1998) Medical Costs and Lost Productivity from Health Conditions at Volatile Organic Compound-Contaminated Superfund Sites. *Environmental Research* 79 (1): 9-19.

Mathews, K. E., K. J. Gribben, and W. H. Desvousges (2002) Integration of Risk Assessment and Natural Resource Damage Assessment: A Case Study of Lavaca Bay. *Human and Ecological Risk Assessment: Theory & Practice*, Dennis J. Paustenbach, ed. New York: John Wiley and Sons.

Mazur, A. (1998) *AHazardous Inquiry: The Rashomon Effect at Love Canal*. Cambridge, Harvard University Press.

McClelland, G. H., W. D. Schulze, and B. Hurd (1990) The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site. *Risk Analysis* 10(4): 485-97.

McCluskey, J. J. and G. C. Rausser (2003a) Stigmatized Asset Value: Is It Temporary Or Long-Term? *Review of Economics and Statistics* 85(2): 276-285.

McCluskey, J. J. and G. C. Rausser (2003b) Hazardous Waste Sites and Housing Appreciation Rates. *Journal of Environmental Economics and Management* 45(2): 166-176.

McConnell, K. E. (1993) Indirect Methods for Assessing Natural Resource Damages Under CERCLA. *Valuing Natural Assets: The Economics of Natural Resource Damage Assessment*. R. J. Kopp and V. K. Smith. Washington, DC, Resources For the Future: 153-203.

McCunney, R. J. (1996) Emergency Response to Environmental Toxic Incidents: The Role of the Occupational Physician. *Occupational Medicine-Oxford* 46(6): 397-401.

McMillen, D. P. (2003) The Aroma of Tacoma: Time Varying Average Derivatives and the Effect of a Superfund Site on House Prices. *Journal of Business & Economic Statistics* 21(2): 237-246.

McMillen, D. P. and P. Thorsnes (2000) The Reaction of Housing Prices to Information on Superfund Sites: A Semiparametric Analysis of the Tacoma, Washington Market. *Advances in Econometrics* 14: 201-228.

Mendelsohn, R., D. Hellerstein, M. Huguenin, R. Unsworth, and R. Brazee (1992) Measuring Hazardous-Waste Damages with Panel Models. *Journal of Environmental Economics and Management* 22(3): 259-271.

Messer, K. D., W. D. Schulze, K. Hackett, T. Cameron, and G. McClelland (2006) Can Stigma Explain Large Property Value Losses? The Psychology and Economics of Superfund. *Environmental & Resource Economics* 33(3): 299-324.

Michaels, R. G. and V. K. Smith (1990) Market-Segmentation and Valuing Amenities with Hedonic Models - The Case Of Hazardous-Waste Sites. *Journal of Urban Economics* 28(2): 223-242.

Morey, E. R., W. S. Breffle, R. D. Rowe, and D. M. Waldman (2002) Estimating the Damages from Injuries to Trout in Montana's Clark Fork River: Summary of a Natural Resource Damage Assessment. *Journal of Environmental Management* 66(2): 159-170.

Northridge, M. E., G. N. Stover, J. E. Rosenthal, and D. Sherard (2003) Environmental Equity and Health: Understanding Complexity and Moving Forward. *American Journal of Public Health* 93(2): 209-214.

Office of Management and Budget (2003) Performance and Management Assessments. Washington, DC: 298.

Office of Superfund Remediation and Technology Innovation (2008) Technical Assistance Services for Communities. Washington, DC.

Office of Technology Assessment (1989) Coming Clean: Superfund Problems Can Be Solved. Washington, DC, U.S. Congress: 223.

Ozonoff, D. (2003) Superfund Basic Research Program: A Model for Contemporary Research Programs. *Environmental Health Perspectives* 111(3): A140-A141.

Palmquist, R. B. (1992) A Note on Transaction Costs, Moving Costs, and Benefit Measurement. *Journal of Urban Economics* 32(1): 40-44.

Pindyck, R. S. (2000) Irreversibilities and the Timing of Environmental Policy. *Resource and Energy Economics* 22(3): 233-259.

Reichert, A. K. (1997) Impact of a Toxic Waste Superfund Site on Property Values. *The Appraisal Journal* 65(4): 381-392.

Rosen, S. (1974) Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economics* 82(Jan/Feb): 34-55.

Satterfield, T. A., P. Slovic, R. Gregory, J. Flynn, and C. Mertz (2001) Risk Lived, Stigma Experienced. *Risk, Media and Stigma*. J. Flynn, P. Slovic and H. Kunreuther. Sterling, VA, Earthscan Publishers: 69-83.

Schulze, W. D., K. Messer, K. Hackett, T. Cameron, and G. McCelland (2004) Stigma: The Psychology and Economics of Superfund. Washington, DC, U.S. Environmental Protection Agency: 228.

Sheldrake, S. and M. Stifelman (2003) A Case Study of Lead Contamination Cleanup Effectiveness at Bunker Hill. *Science of the Total Environment* 303(1-2): 105-123.

Smith, V. K. and W. H. Desvousges (1986) The Value of Avoiding a Lulu: Hazardous Waste Disposal Sites. *Review of Economics and Statistics* 68(2): 293-299.

Thayer, M., H. Albers, and M. Rahmatian (1991) The Benefits of Reducing Exposure to Waste Disposal Sites: A Hedonic Housing Value Approach. *The Journal of Real Estate Research* 7(3): 265-281.

U.S. Environmental Protection Agency (2004) The Superfund Innovative Technology Evaluation Program Annual Report to Congress. Washington, DC, Office of Research and Development: 89.

Wildavsky, A. (1995) *But Is It True? A Citizen's Guide to Environmental Health and Safety Issues*. Cambridge, Harvard University Press.

Williams, P. R. D. and D. J. Paustenbach (2002) Risk Characterization. *Human and Ecological Risk Assessment: Theory and Practice*. D. J. Paustenbach. New York, John Wiley & Sons: 293-366.

Zeitz, P., Z. Berkowitz, M. Orr, G. S. Haugh, and W. E. Kaye (2000) Frequency and Type of Injuries in Responders of Hazardous Substances Emergency Events, 1996 to 1998. *Journal of Occupational and Environmental Medicine* 42(11): 1115-1120.

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