Information Flows and the Impact of PCB Contamination on Property Values

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Abstract

This thesis uses hedonic techniques to quantify the industrial externalities that are capitalized into property values. We show that Pittsfield residents are willing to pay more money to live further away from the PCB contaminated General Electric complex, and furthermore that the effect of this change in demand increases fourfold after the Superfund announcement. Information dissemination is also examined to see the process and speed through which these externalities have been capitalized into the real estate market.

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Part I

Introduction

Modern society is characterized by a prevalence of industrial production, and accordingly by waste and pollution as natural derivatives. In a well-regulated society, in which companies are financially responsible for all pollutants, the pollution costs from waste would be internalized, i.e. the firms would have an incentive to take those costs into account in their decisions. Unfortunately, in many societies, untaxed and unregulated waste disposal and pollution become a serious community issue of enormous social costs that citizens must confront. While environmental damage is readily observable, it is often very difficult to measure, especially in the sense of welfare cost to society. As a result, the design and implementation of environmental/ pollution policies are complicated by a variety of issues: the difficulty of measuring the damages to the environment and society; the difficulty of determining and collecting a full set of data necessary for a well-informed solution; and the inclusion of controversial value judgments necessary for reaching a solution.

This thesis is a specific case study that examines the general feasibility of measuring the costs of environmental damage using information about residential housing sales. This technique for analyzing environmental damage is broadly applicable to a variety of location-linked risks and is useful for proposing methods of compensation and perhaps a cleanup or removal of the pollutants. This thesis also examines the interactive effects of information dispersal and environmental damage, and the resulting capitalization in real estate markets.

Economic Evaluation of Externalities Arising from Industry

The following theoretical approach to measuring total social loss as a consequence of industrial externalities shows how the exclusion of the incidental cost of pollution from an industry's cost structure falls on those not directly involved in the polluting economic activity. Subsequently, the following section shows how these externalities are capitalized into real estate market prices.

As shown in Figure 1, a market *with* negative production externalities produces at quantity Q_c, where the marginal social benefit curve (MSB), or demand curve, intersects with the marginal private cost curve (MPC), or supply curve. At this equilibrium quantity, Q_c, the consumer pays the competitive market price P_c, where MPC=MSB. However, at Q_c, society as a whole pays P_a, the sum of the market price, P_c, plus the marginal incidental costs of pollution borne by those not included in the original market transaction, P_a- P_c. The cost to society is measured at the marginal social cost curve (MSC), and the height between the MSC and the MPC, is the marginal external cost, or MEC.

The socially optimal market, on the other hand, includes market and government mechanisms, such as property rights, that require compensation for all damage imposed on third parties, such as the release of pollution. The resulting incorporation of pollution costs into the industry's cost structure raises the MPC curve to a new supply curve at MSC, where all parts of the polluting activity are included in the industry's cost structure. In Figure 1, we see that Q* is the optimal quantity of production where MSB=MSC. In other words, the socially optimal equilibrium occurs when all costs related to the market transaction are faced by the private decision makers, at the margin. The socially optimal price, P*, is higher than P_c because it includes a portion of the pollution costs that the polluting industry has passed along to the consumer.

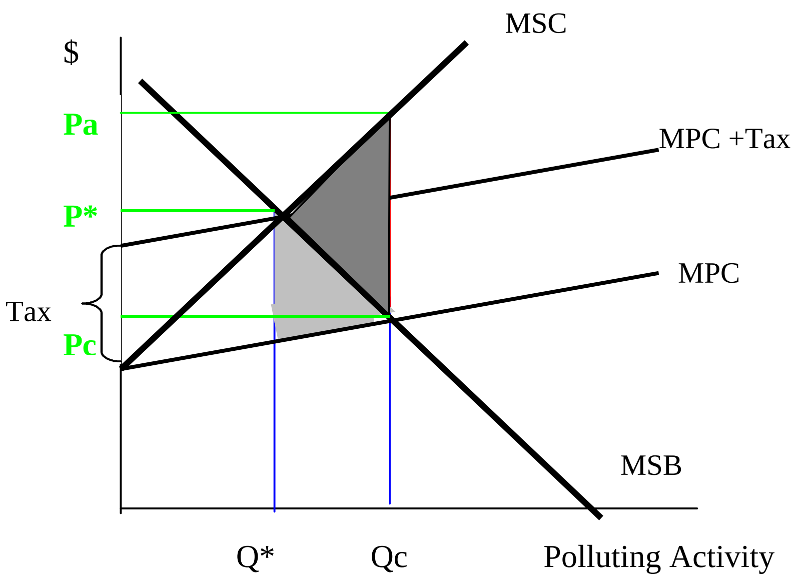


Figure 1

Pa-Pc= external or incidental cost
P*= socially optimal price
Pc= non-optimal market price

Comparing these two market scenarios, the dark gray shaded portion of Figure 1 indicates the deadweight loss to society, or the additional costs borne by society beyond those included in the market transaction. The dead weight loss is measured as the sum of incidental costs from Q* to Q_c. This net loss to society is the total *economic* burden of the pollution damages that is imposed on members of society.

Ideally, policy makers will set taxes such that MPC + tax = MSB at the optimal quantity, Q*, located where MSB=MSC. This tax policy reduces the quantity of the polluting activity and internalizes the remaining pollution costs into the market transaction such that society no longer bears the burden of the incidental costs of pollution.

Integrating from 0 to Q_c between the MSC and MPC curves, we can measure the value of the external damage to society from pollution production between 0, where there is no polluting activity, and Q_c. This value of external damage is seen as the white, light gray, and dark gray triangles in Figure 1. The tax equilibrium quantity Q* eliminates the damages shown in the two gray triangles, and allows a socially optimal level of pollution, the white triangle. In other words, the tax policy eliminates this dead weight loss to society, the dark gray triangle, and further diminishes the pollution damages by the light gray triangle.

While this graph demonstrates only theoretically the magnitude of efficiency loss and damage to society, it is possible to begin calculating the magnitude of these costs by measuring the external costs revealed by differentials in residential property values. A hedonic model, as will be discussed later, can help calculate a portion of the efficiency loss, using the aggregate loss of residential property value, as a function of the industry-caused disamenities. This aggregate loss to property value can thus reveal a significant proportion of the monetary value of the damages, or at least a lower bound of the potential value-range of damages.

The Capitalization of Externalities into the Real Estate Market

A close look at the relationship between externalities and the real estate market illustrates how homeowners include current and future disamenities and risks in their criteria for purchasing a home. This process of capitalization is defined as the calculation of the current value of a future stream of earnings or cash flows. For example, a prospective homebuyer will base his/her bid price on the risk-adjusted present value of a future stream of net benefits that he/she expects to receive by virtue of owning and occupying the home. Since the stream of benefits plays out over time, there is a natural uncertainty about the magnitude to be received. This uncertainty is further confounded by the potential reduction of expected benefits as result of nearby industrial disamenities, perceptions of current health risks, and the perceived risk of future environmental hazards as signaled by the media and EPA declarations.

Industrial disamenities such as the view of an industrial complex, pollution, ground water contamination, and property damage like soil contamination, can potentially reduce the benefits of owning a home. In a similar light, underused or abandoned industrial facilities, known as brownfields, have negative effects on urban economies and property values. Examples are visual blight, urban sprawl as companies pass over potentially contaminated sites for new greenfields, and outward migration for jobs and more attractive homes.

Perceptions of current health risks and future environmental hazards are often based on information received by word of mouth or from newspaper articles and other media such as movies and the news. An individual's perception of health risks evolves with each morsel of additional information regarding health and environmental risks associated with the industrial complex and its externalities. In this way, current and future risks are continually communicated to a buying public that is concerned about negative outcomes and the potential affect on property.

EPA announcements about the severity of environmental damage and risks to humans can also signal future risks to individuals. In the case of a Superfund declaration, it is ambiguous whether an individual will perceive the announcement and the consequent cleanup as an improvement in future benefits, or a disclosure and/or confirmation of the severity of the current risks and thus a deterioration of future benefits.[1]

Consider a scenario in which there are a substantial number of uncertainties about the current and future risks associated with living near an industrial facility. In this case, given ample information dissemination, individuals will absorb these uncertainties and incorporate them in their risk perceptions. As prospective homebuyers, individuals will capitalize these risk perceptions into a home's value, and thus reduce their bid according to the externality-based reduction of future benefits associated with that home. Approached differently, the amount of discount on the real estate bid is the dollar amount of compensation necessary for the prospective buyer to put himself/herself in harm's way, as a resident of this home. This demanded discount, or capitalized external cost, is the present value of external costs borne each year, by the resident, over the life of the house. Furthermore, these risks will affect the future resale value of the property and as a result, this too is included into the present purchase bid.

It is thus to be expected that externalities cause a reduction in house values for those purchased after risk information is dispersed and capitalized into the real estate market. Yet, for homes not on the market, it is reasonable to assume that the value of these homes is *also* reduced when current and future risks associated with the industrial facility are included in the value capitalization. In this case, homeowners who already own the property before the negative externalities become apparent, suffer a capital loss as the external damage is capitalized into the price of their property. To comprehend this issue, we must remember that capitalization damages might occur at a pivotal moment when information is released in the media, such as an announcement that a nearby

[1] Please see the following section for an explanation of Superfund and other environmental laws.

landfill or industrial complex has been included on the National Priorities List (NPL). Furthermore, these value damages can continue to accrue as more risk information is made available and included in real estate market decisions. Please note that these announcements will only reduce home values if they reveal that the damage is likely to be worse than previously expected. Thus, as mentioned above, the information dispersal process is continual and, as a result, there may be continual reductions in the value of a home.

Superfund and Other Environmental Laws

EPA announcements and environmental laws play an important role in risk perceptions and, as a result, in real estate markets. While these laws are designed to protect people and the environment, they also send signals about the severity of current and future risks that result from industrial externalities, such as pollution.

Superfund is the commonly used name for CERCLA, the Comprehensive Environmental Response, Compensation, and Liability Act, which was enacted by Congress in 1980. CERCLA provided broad Federal authority to respond to environmental and public health hazards and the National Contingency Plan (NCP) outlined the procedures and guidelines for hazard removal, in addition to establishing the NPL. In 1986, CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA).

Inclusion on the National Priorities List requires meeting one of the three following criteria: [i]

1. A high rank in EPA's Hazard Ranking System (HRS) based on the following items:
    - likelihood that a site has released or has the potential to release hazardous substances into the environment;
    - characteristics of the waste (e.g. toxicity and waste quantity);
    - people or sensitive environments (targets) affected by the release.
    - ground water migration (drinking water);
    - surface water migration (drinking water, human food chain, sensitive environments);
    - soil exposure (resident population, nearby population, sensitive environments); and
    - air migration (population, sensitive environments).
2. A state's designation of the hazard as their one top-priority site regardless of the HRS score;
3. all three of the following criteria:
    - The Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Public Health Service has issued a health advisory that recommends removing people from the site;
    - EPA determines the site poses a significant threat to public health; and
    - EPA anticipates it will be more cost-effective to use its remedial authority (available only at NPL sites) than to use its emergency removal authority to respond to the site.

Source: www.epa.gov

Hedonic Analysis

Now that we have examined how external costs are capitalized into the real estate market, we use hedonic analysis to determine the magnitude of these costs.

The hedonic approach to price determination is important for valuing heterogeneous products such as automobiles and houses. While houses are traded in a single market, the houses have different characteristics and widely varying prices, and this makes price determination difficult compared with other markets. One way to clarify this difficulty, is to think of houses as different bundles of homogenous components, like bedrooms and bathrooms. Through an analysis of local real estate information, we can disaggregate the demand for houses into demand for individual (relatively homogenous) housing characteristics. The estimated hedonic prices reveal information about consumer preferences and their marginal willingness to pay for a particular housing attribute, in that specified market.

It is implicit in this hedonic model and in the nature of heterogeneous products that a variety of bundles are available so that a customer can choose any combination of attributes they want, and are thereby constrained only by their income and the price of the desired bundle (house). Accordingly, a consumer purchases a house at an optimal level where the consumer's marginal willingness to pay for each characteristic equals the hedonic price (or marginal cost) of that characteristic.

Following this reasoning and assuming that the hedonic price function can be accurately estimated, the hedonic price of each housing attribute will represent an individual's marginal willingness to pay for that characteristic and can be summed to determine the price an individual will pay for the entire bundle, or house. This can be extended to measure a consumer's marginal willingness *to pay for, or pay to avoid*, different variables like neighborhood and location characteristics such as schools and pollution. In other words, a hedonic model can be used to measure the portion of a house's price that is affected by pollution, such as PCB contamination, or other disamenities. In this way, we can determine the devaluation effects that externalities have in the real estate market. An alternative interpretation is that a hedonic model measures how much of the external cost of a polluting industry is absorbed by individuals buying and selling a home with disamenities considered to be part of the house's bundle of characteristics.

Determining the magnitude of damages and efficiency loss is important for litigation purposes, social policy issues, and economic development, among other things. The hedonic model provides information about the monetary value of damage affecting individual homes at a given point in time and space. If the negative externalities were not present, the value of the home would be equal to those with the same building characteristics and location amenities. In this regard, hedonic models enable analysts to separate out characteristics of a home and its location amenities which further enables the pinpointing of key determinants of value. Without such a model, lawyers or policymakers have little more than a "feeling" and circumstantial evidence that pollution, contamination, distance, etc. are negatively affecting residential property values. With such specific and "accurate" data in hand, lawyers and courts can compel companies to pay restitution for damages.

Hedonic analysis also supports policy makers when they take the political and legal risks involved in placing the burden of externalities on big corporations through a tax on pollution. The specific quantification of damages calculated in the hedonic analysis helps determine the efficient taxing policy for polluting industries, as shown in Figure 1.

Finally, the methods of economic development can be better informed by comparing case studies of similar industrial companies, notorious for pollution. While a developing region might perceive polluting industry as advantageous in the short-run, they must keep in mind the social efficiency losses from externalities and other events that depress economies. Accordingly, policy makers in developing countries, or in regions seeking to promote economic growth (like the Berkshire County) can take this information into account in their cost-benefit analysis of including certain types of industry in their economy, thus leading to a more well informed decision.

Literature Review

Economists have conducted a variety of studies using hedonic models to evaluate the effect of disamenities on residential property values. The typical disamenities studied range from nuclear power plants, hazardous and radioactive waste landfills, earthquakes and other natural disasters, to noise and air pollution. There has been a mixed bag of results often due to circumstantial factors. For example, property near a new landfill in a rural area was highly valued due to new infrastructure (Pettit and Johnson 1987). Expensive homes sprung up around another aging landfill in response to a promised golf course to be built on the capped landfill (McClelland 1990). Residents near Three Mile Island saw the reactor disaster as a short-term risk and property values returned to normal in four-to-eight weeks (J. Nelson 1981 and B.A. Payne 1987). And, despite expert assertion that an area (just outside the evacuated area after the Love Canal disaster of 1978) met the required health safety levels, individuals and property values were still influenced by fears of health threats (Payne 1987).

Despite these varied results, several studies have found results that are applicable to the Pittsfield GE site: the relationships between property devaluation and a) distance from the site in question, b) announcements regarding site pollution and contamination, and c) remediation of the site in question.

Using hedonic models to "tie property values to the proximity of factories, air pollution, highway noise, and other stresses through mathematical equations," (Greenberg and Schneider, 1996, p. 43), economists have used the resultant equation coefficients "to estimate the economic impact of the hazard on the neighborhood and the economic benefit of remediating the hazard," (Greenberg and Schneider, 1996, p. 43). Using these methods, researchers have found that toxic waste sites have an effect on property value as a function of distance and that the hazard typically lowers property values from 5 to 10 percent within one-quarter mile of a site (Greenberg and Hughes [1993]; Hoehn, Berger, and Blomquist [1987]; McClelland, Schulze, and Hurd [1990]; Skaburskis [1989]; Havlicek [1985]; Adler [1982]; and A. Nelson [1992]).

Additionally, reporting on the results of various hedonic models, Gerrard (1994) observes that "most of these studies show a strong negative correlation between proximity to a hazardous and/or radioactive waste (HW/RW) disposal site and property values, especially after publicity concerning the site or concerning other contamination incidents. A strong negative effect can result from the mere announcement that a facility will be built… Overall, the evidence exists that in at least some communities HW/RW facilities are lowering property values," (Gerrard, 1994, p. 72).

Janet Kohlhase has taken this approach further by analyzing the effects of hazard related announcements about the opening of a hazardous landfill, the closing or remediation of a landfill, and finally about the true levels of contamination and "threats" to nearby residents. Kohlhase recognizes the effect of announcements on communities in that they change perceptions of the hazard and give a different estimation of the involved danger in a case where it is difficult for an individual to assess the dangers.

While analyzing the impact on real estate markets of EPA announcements and different hazard related policy actions, Kohlhase found that EPA announcements that a toxic waste site is on the Superfund list increased the demand for “safe housing”. In other words, a premium would be paid for homes further away from the contamination. This effect on the market for “safe housing” occurs even when there is an announcement about a future landfill, to be built in the area. In other words, even the knowledge of potential future threats can create this market for “safe housing”.

For example, she noted that a significant discount in the price of a Houston area home, located close to the toxic waste dumps, is found only after the sites have been identified and publicized by the EPA. This lagged effect of announcements is primarily due to a market imperfection in which consumers are unable to differentiate between the degrees of toxicity of sites. Interestingly, the residents adjusted their perceptions based on the “condition or title” of the hazardous waste site such as whether a waste site was open or permanently closed, open, etc. regardless of the underlying real levels of contamination and threat.

Reversing the above process, the price differentials disappear as quickly as they appear in the case of remediation and announcements that a site will close. This effect of remediation on price differentials is important because it allows us to evaluate the effectiveness of remediation. Specifically, policy makers can assess whether remediation has been effective in reducing, if not eliminating, the industrial externalities born by society.

A recently published study incorporated a Bayesian learning model into a hedonic framework in order to estimate the value that residents place on avoiding cancer risks from hazardous-waste sites (Gayer, Hamilton, Vicusi 2000). In this model, the residents’ cancer risk assessments were shaped by the local media, the initial individual assessments associated with the Superfund announcement, and later by the EPA's assessment of the site risks (contained in the site Remedial Investigation report). While Kohlhase hypothesized that the Superfund declaration hype aided residents in an elevated and "more accurate" knowledge of the contamination, Gayer *et al* comment that the Superfund hype leads residents to overreact about potential health risks. Gayer *et al* further comment that the EPA's release of the Remedial Investigation further alters residents' risk beliefs. "The release of the EPA's Remedial Investigation provided risk information that lowered perceptions of the risk, which were initially alarmist, resulting in a decrease in magnitude of the price-risk gradient," (Gayer *et al*, 2000, p. 447). Gayer's results also indicate that, when controlling for the real risk level, newspaper publicity about Superfund sites has a negative effect on housing prices. The effects of publicity were the same before and after the release of the Remedial Investigation which suggests that the publicity did not, for example, communicate new information about health risks that was previously unavailable, but rather heightened the awareness about that information. This further supports another study (Combs & Slovik, 1979) that suggested that substantial newspaper coverage led to an overestimation of mortality risks.

Part II

Thesis

This thesis aims to determine what has been the monetary value of impact on residential property in the city of Pittsfield from the pollution that has occurred at the Pittsfield General Electric complex and extending into the Housatonic River. If such an impact is found, this thesis will characterize the manner in which information flows create the market impact.

Case Study Background

The Pittsfield General Electric complex is a classic example of an aged industrial site that has a long history of hazardous waste disposal, in addition to a substantial portion of acreage that lies unutilized, despite its prime location. This underused land is called a brownfield, which is characterized by difficulties in redevelopment because of real or suspected contamination. General Electric's past polluting behaviors (Polychlorinated biphenyls, or PCBs)[2] and the resulting brownfield site cause negative externalities that constitute market failures, and that are furthermore associated with an improper specification of property rights and/or insufficient regulation of industry.

Since the late 1970's, when the EPA banned the use of PCBs, new information has come to light about the health hazards associated with PCBs and other hazardous chemicals, as well as the risks associated with improper disposal methods. This research does not evaluate the legal liability associated with GE's behavior or the extent to which that behavior was negligent. Nor does the analysis provide a particular condemnation of

[2] PCBs, polychlorinated biphenyls were used by General Electric as a fire-proof insulator for electrical transformers.

GE's decisions. Economists often leave these normative questions to the courts and concentrate on the calculations of the magnitude of damages incurred. This information will enable the discussion toward a more productive assessment of the costs and benefits that will reveal the financial feasibility, or perhaps unfeasibility, of a removal of the hazardous materials.

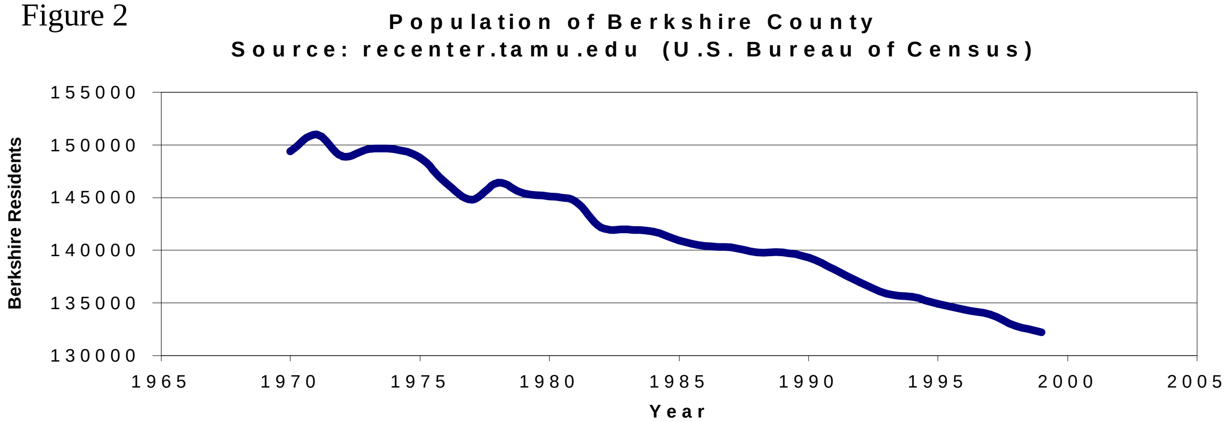
Pittsfield, Massachusetts and General Electric

The rise and fall of American industry has played an important role in shaping both the history and the present structure of Pittsfield, as it has for many other New England industrial towns. When Pittsfield became a city in 1891, it already had a long history marked by agriculture and industries such as textiles, wool, cotton, shoes and paper. During the final years of the 1800s, the textile industries began to decline and many small businesses were established in Pittsfield, such as the Berkshire Brewing Association, Eaton-Hurlbut Paper Co., Berkshire Automobile Co. and Berkshire Mutual and Berkshire Life Insurance Companies.[ii]

In 1886, William Stanley demonstrated the first AC (alternating current) transformer and established the Stanley Electric Manufacturing Company in Pittsfield. The AC transformer enabled the transmission of electricity over long distances as well as the necessary reduction in voltage for consumer purposes. In 1890, Stanley Electrical Manufacturing Co. employed over 5,000 Pittsfield residents and manufactured transformers, auxiliary electrical equipment, and electrical appliances. General Electric (GE) purchased Stanley Electric in 1903 and later dominated the Pittsfield economy during much of the 20th century. During World War II, GE employed 13,645 Pittsfield residents and in the 1950's, General Electric employed 3 out of 4 Pittsfield workers in the Ordnance and Transformer plants, in addition to other GE enterprises. In other words, Pittsfield was the classic "company town." Soon after, General Electric established the GE Plastics headquarters in Pittsfield. In the 1970s and 1980s, downsizing throughout all of GEs facilities heavily impacted the Pittsfield economy.[iii]

Since 1971, Berkshire[3] County's population has experienced a slow and steady decline of about 0.4% per year with a total population decrease of 11.5% from 1970 to 1999, the majority of which is net domestic migration (see Figure 2). In 1990, Pittsfield's population was 48,792 and in 1999 the population was 45,296, a 7.2% decrease over nine years. The overall labor force has followed a similar trend, decreasing by 2.7% from 1983 to 1990, and by almost 12% from 1990 to 1999. The most striking decline has been in the manufacturing laborforce, which has declined by 34.5% from 1985 to 1990, and overall by 56% from 1985 to 1999 (see Figure 3). Additionally, Pittsfield's unemployment rate has been on average 1.6% higher than that of Massachusetts (see Figure 4). Finally, from 1985 to 1993, income per capita in Pittsfield was 15.7% less than income per capita for Massachusetts as a whole. From 1994 to 1999, Pittsfield's income per capita was even lower, at 26% less than the state average (see Figure 5).

Figure 2



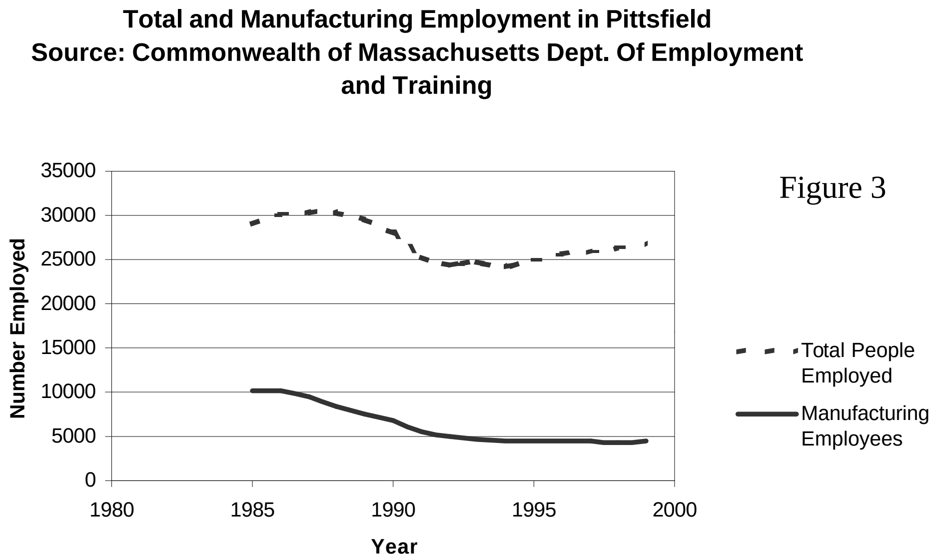


Figure 3

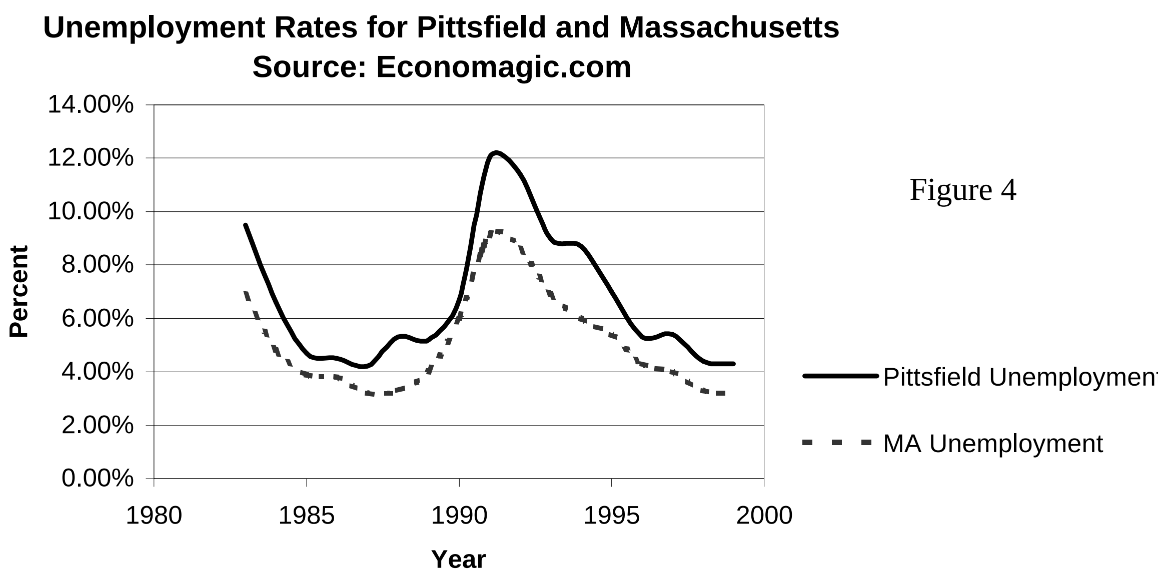


Figure 4

[3] The western quarter of Massachusetts is the Berkshire County and Pittsfield is the county seat.

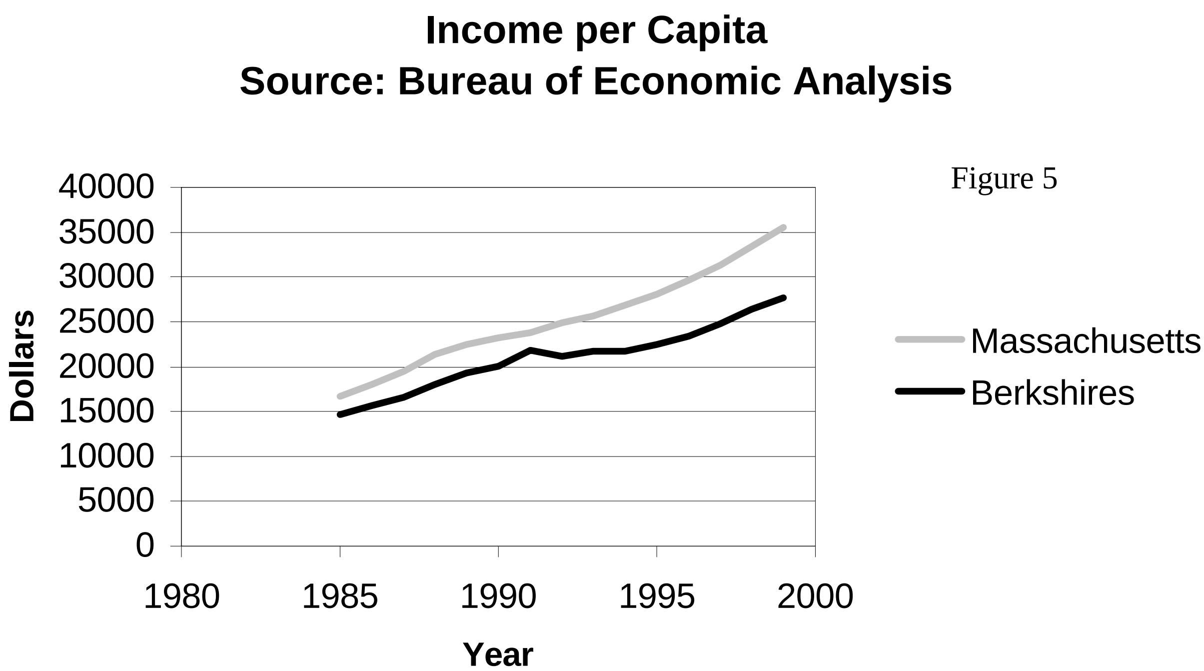


Figure 5

In 1903, after purchasing Stanley Electric, General Electric continued to manufacture electrical capacitors and transformers at the Pittsfield plant. From 1932 to 1977, workers used polychlorinated biphenyls (PCBs) during the transformer testing, manufacturing, and repairing processes as a non-flammable insulation material. An estimated million and a half pounds of PCB oil and PCB waste products were spilled in the plants, draining through the floors, into the groundwater, and eventually into the Housatonic River.[iv]

Located about one kilometer east of downtown Pittsfield, this 254-acre GE complex of industrial buildings and landfills dominates the Pittsfield landscape (see Figure 6). On this map, the colored areas are contaminated with PCBs and industrial solvents, and the numbered buildings are part of the General Electric Complex. All of the other gray figures are residential homes and commercial buildings. While this enormous complex was once the heart of the Pittsfield economy, much of the land is now considered to be a brownfield, underused and contaminated. The PEDA, Pittsfield Economic Development Association, is working with General Electric and various agencies to clean up the site and prepare it for future industry.

The Early History of Regulatory Involvement at the General Electric Site

Since the early 1980s, the EPA and the Massachusetts Department of Environmental Protection (MADEP) have investigated the GE Pittsfield/Housatonic River site and, with the help of General Electric, conducted short-term cleanups. These two agencies worked under a variety of regulatory mechanisms such as Administrative Consent Orders (ACOs) and Corrective Action Permits under the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act (RCRA). In 1991, the EPA issued a RCRA Corrective Action Permit that "included the entire 254-acre facility, some former fill oxbows, Silver Lake, the Housatonic River and its floodplains and adjacent wetlands, and all sediments contaminated by PCBs migrating from the GE facility," (www.epa.gov/region01/ge/sitehistroy.html).

In 1982, due to PCB contamination in river sediments and fish tissue, the Massachusetts Department of Public Health (MADPH) issued a fish consumption advisory for the Housatonic River that was later extended to include fish and turtles.

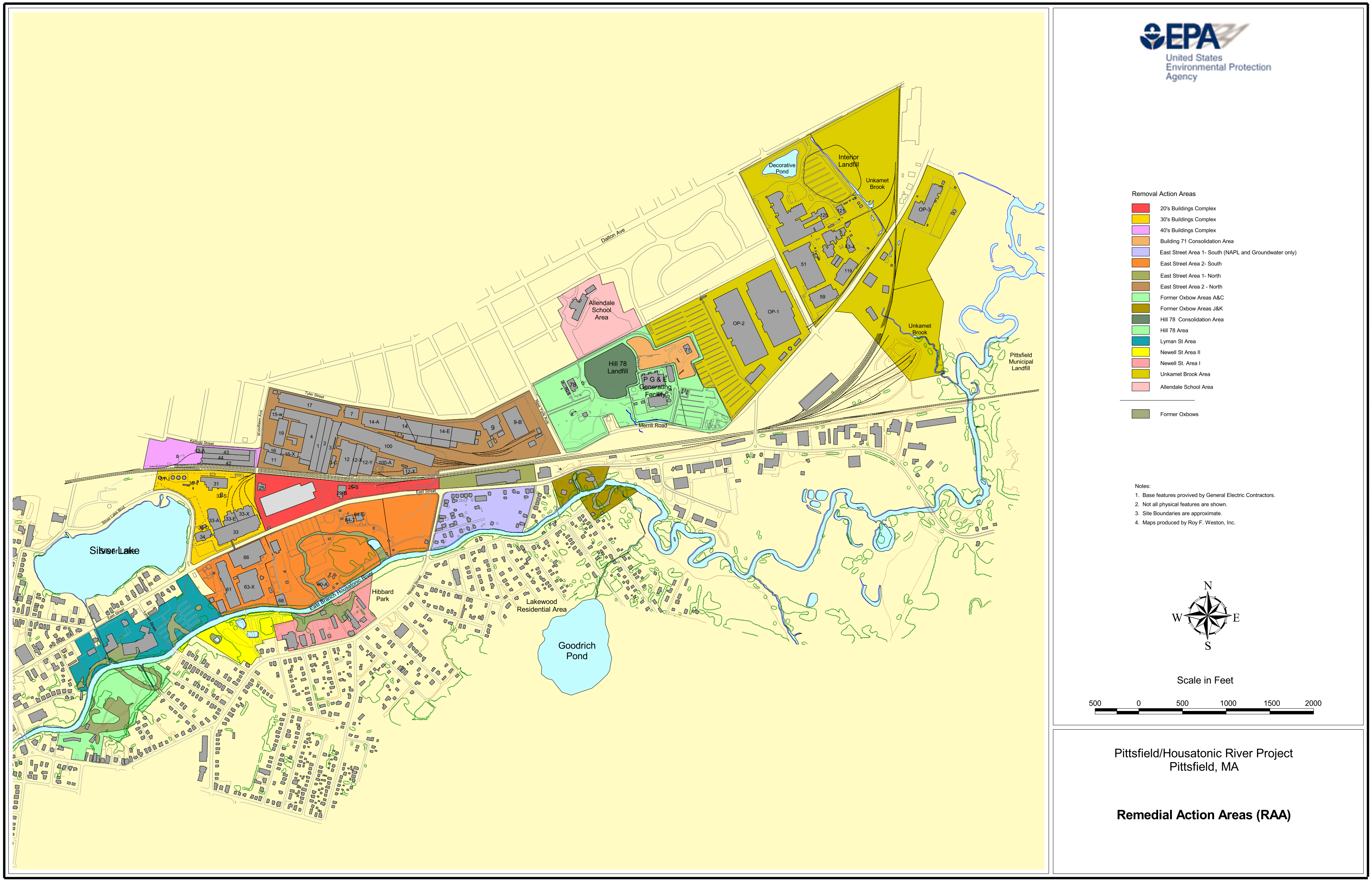

United States
Environmental Protection
Agency
Removal Action Areas
20's Buildings Complex
30's Buildings Complex
40's Buildings Complex
Building 71 Consolidation Area
East Street Area 1- South (NAPL and Groundwater only)
East Street Area 2- South
East Street Area 1- North
East Street Area 2 - North
Former Oxbow Areas A&C
Former Oxbow Areas J&K
Hill 78 Consolidation Area
Hill 78 Area
Lyman St Area
Newell St Area II
Newell St. Area I
Unkamet Brook Area
Allendale School Area
Former Oxbows
Notes:
1. Base features provided by General Electric Contractors.
2. Not all physical features are shown.
3. Site Boundaries are approximate.
4. Maps produced by Roy F. Weston, Inc.
Scale in Feet
500 0 500 1000 1500 2000
Pittsfield/Housatonic River Project
Pittsfield, MA
Remedial Action Areas (RAA)
Silver Lake
Goodrich Pond
Hibbard Park
Lakewood Residential Area
Allendale School Area
Hill 78 Landfill
P G & E Generating Facility
Decorative Pond
Interior Landfill
Unkamet Brook
Pittsfield Municipal Landfill
Dalton Ave
Merrill Road
East Street
Tyler Street
OP-1
OP-2
OP-3

Figure 6

In 1999, the MADPH issued a waterfowl consumption advisory due to potential health risks related with the consumption of PCB contaminated animals.

The Superfund Announcement and the Law

On Monday August 4, 1997, EPA administrator John DeVillars formally nominated the GE/Pittsfield site and 55 miles of the Housatonic River for inclusion on the National Priorities List (NPL) of Superfund. This announcement signaled to the public, General Electric, and environmental agencies that the dangers associated with the past and future release of PCB oil into the environment, while not immediately life threatening, are serious enough to warrant EPA action and removal of the PCB contamination. Furthermore Superfund designation allows the Federal government to order cleanup activity, and if GE refuses to pay, the EPA can take action and then sue not only to recover its cost but triple damages.[v] In other words, a Superfund designation means that the contamination will be cleaned up.

In response to the announcement, General Electric and the City of Pittsfield negotiated with the EPA, to **preclude** the site's inclusion on the National Priorities List. GE preferred to negotiate each step of the cleanup process with the EPA rather than risk paying in a court settlement after an EPA cleanup. The City of Pittsfield, on the other hand, wanted to avoid the Superfund stigma that would damage the local economy, decrease residential and commercial property values, and damage the mechanisms for economic development. For example, placing the Superfund stigma on the GE complex would further deter any prospective companies from moving onto vacant portions of the complex. As a result, the EPA has proceeded without a full NPL designation and has negotiated with GE and Pittsfield, about every portion of the Consent Decree, which outlines the cleanup procedures and apportionment of costs.

Polychlorinated Biphenyls (PCBs)

United States law **required** the use of polychlorinated biphenyls (PCBs) in electrical transformers and capacitors because of their spark-resistant qualities as a non-flammable insulation material. In 1977, the U.S. halted the manufacture of PCBs based on EPA evidence that PCBs build up in the environment and cause harmful effects to human health.[vi]

PCBs, polychlorinated biphenyls, are a distinct group of chemical compounds that do not occur in nature, nor for that matter do they break down easily in the environment. Until they were banned in 1977, PCBs were used in capacitors, transformers, hydraulic fluids, lubricants, pesticide extenders, sealants and flame-retardants. While there are a variety of trademarked names for PCBs, Aroclor and Pyranol were those most commonly used by General Electric. GE purchased liquid PCBs from chemical manufacturers, primarily Monsanto Industrial Chemical Company, and mixed the PCBs with synthetic oil and other chemicals such as chlorinated napthalenes. A variety of formulas were used for various transformer types, and as a result, scientists can determine the source of a leak within a plant. Similarly, the distinct PCB mixtures used by General Electric in Pittsfield can be distinguished chemically from those used by Sprague Electric in North Adams. General Electric is known to be the sole user of PCBs in the Housatonic River watershed.[4]

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[4] Sprague Electric in North Adams used PCBs although the factory was located in the Northern Berkshire County as part of the Hoosic River watershed.

It is reasonable to assume that the majority of PCB contamination is in the form of mixed formulas of PCBs, synthetic oil, and other chemicals. Pure PCBs may have spilled from the General Electric's storage tanks, but scientific research has shown that as a pure liquid, PCBs will travel only short distances through the ground under extremely strong pumping.[vii] Additionally, the contaminated Fuller's Earth, a glorified kitty litter, contains PCB oil and transformer parts because it was used to filter the PCB oil and to clean up floor spills. For the most part I use "PCBs" to denote both PCB-laden oil and the molecules themselves. In the health effects section, the research examines only the effects of the PCBs molecules and not the associated oil and chemicals.

Before proceeding further, it is best to illustrate the contaminated areas that will be discussed and the basic behavior and movement of PCB oil.

General Electric's network of pipelines and storage and mixing tanks are the primary source of the PCB oil plumes and the PCB contamination in the Housatonic River, Unkamet Brook, and Silver Lake. These pipelines and tanks leaked and at times collapsed, releasing PCB-laden oil straight into the soil, surface water, and ground water.[viii] During 1968, a PCB storage tank in Building 68 of the Pittsfield/GE facility collapsed, releasing about 1000 gallons[ix] of liquid Aroclor 1260 onto the Housatonic riverbank and into the sediment.[x] The leaking PCB oil seeped into the ground beneath the GE complex and collected in large plumes, several feet thick, which flow along hydrogeologic surfaces to the Housatonic River.

The majority of the plumes, or underground masses of PCB-contaminated oil, are D-NAPL (dense, non-aqueous[5] phase liquid hydrocarbons), and thus sink beneath the ground water, and move along a confining layer of rock. In a few cases, the plumes are L-NAPL (light, non-aqueous phase liquid hydrocarbons), and thus float on the water table. As the plumes leached into the Housatonic River, the heavier D-NAPL oil sunk to the bottom and collected in the riverbeds and sediment, and the lighter L-NAPL oil created an oily sheen over the water surface.[xi]

The EPA and Department of Environmental Protection (DEP) have estimated that there are millions of gallons of PCB oil floating on the ground water, in the soil beneath the General Electric complex. "GE first started trying to control these plumes in the mid-1970s by building underground barrier walls and installing active pump-and-treat systems" (Theo Stein, Berkshire Eagle, 1/12/1999). In order to avoid additional leakage from the plumes into the river,[xii] GE has constructed barriers of sheet piling along the Housatonic River banks between Newell and Lyman Streets, an area where oil seepage has been observed in the past. In addition, GE has also put up floating booms in the area to capture any lingering oil sheens.[xiii]

Local press reports describe the immensity of the plumes: "One plume was formed by PCB-contaminated mineral oil that leaked from storage tanks near the Building 12 complex north of the railroad tracks. By the mid-1980s, the subsurface plume had created a 19-acre lake[6] of light oil riding on top of the groundwater, with the area of thickest oil covering 11 acres… Since the 1970s, more than 750,000 gallons of oil

[5] Non-aqueous means that the PCBs do not dissolve in water.
[6] This plume corresponds to the largest green plume on the General Electric Map.

have been drawn from [the Building 12 plume and another plume] in the East street area [and] trucked to Texas and burned," (Theo Stein, Berkshire Eagle, 2/25/98).

Figure 7 shows the contamination plumes as green, red, and magenta hatched patches. Note the proximity of these plumes to the Unkamet Brook (under the magenta plume) and the Housatonic River. Through underground leaching processes, the PCB contaminated oil has made its way into the river.

During the transformer manufacturing and testing processes, it was not uncommon to spill PCBs on the factory floor. As mentioned earlier, Fuller's Earth was used to clean/filter the PCBs, as well as clean up spilled PCBs at the GE complex. This material was primarily disposed of in landfills, both on and off the GE complex, such as the Pittsfield Sanitary Landfill and the Superfund Rose Site in Lanesboro, MA.[xiv] The Pittsfield Landfill is located on the East side of the General Electric map and contains over 700 barrels of used PCB oil, toxic solvents, and other waste products from the GE facility.[xv] Two other landfills, the Interior Landfill and the Hill 78 Landfill (located on the north-northeastern edges of the plant), also received contaminated Fuller's Earth.

In addition to landfilling the PCB-laden Fuller's Earth, General Electric shipped fill off-site and dumped it in former oxbows and on residential and commercial properties. The former oxbows are sections of the Housatonic River that were isolated from the main channel when the U.S. Army Corp of Engineers straightened a section of the river to alleviate flood threats to the Lakewood neighborhood in the 1930s.[xvi] The resultant oxbows were used for the dumping of fill and 90% of them are contaminated with PCBs.[xvii] Figure 7 shows many of these former oxbows as army green curves along the Housatonic River. Extending the scope of contamination, General Electric offered both contaminated and uncontaminated fill to contractors, homeowners, and small businesses, as a less expensive means of disposal. During the 1940s and 1950s, GE trucked this free dirt to various properties to be used to fill in low marshy areas and to level off properties.[xviii]

As of November 7, 2000, EPA, DEP and GE have sampled 360 properties; 210 properties have been identified with one detection over 2ppm (some of which do not require remediation); and of those indentified,136 properties have been remediated to an average of 2ppm.[xix]

PCBs in the Environment

The EPA and the DEP have attributed the PCB contamination of the Housatonic River to the contaminated sediments in the former oxbows and plumes leaching from under the GE complex. Once the PCB molecules enter the environment, they attach themselves to sediment, soil, and dust particles and do not detach very easily. In the Housatonic River, the PCBs attach to river sediments or other solid matter, and are carried along, depositing and migrating as is typical of river sediments. During floods, these PCB-laden sediments flow out onto the floodplain and remain behind when the water recedes. As a result, the PCB contamination of the Housatonic River coincides with the ten-year floodplain[xx] and extends down to the Long Island Sound. A ten-year flood is a large flood that typically happens only once in ten years, and accordingly, the ten-year floodplain is the area covered by these floodwaters.

There are some other methods by which PCB contamination can be distributed in the environment. Considering that the PCBs are bound tightly to the fill, the contamination will not move from the fill area or into the groundwater, unless moved by an outside source like people's shoes and clothing. In addition, PCB contaminated *dust* can be stirred up into the air and inhaled, although PCBs themselves are not considered to be volatile (turn from liquid into gas). Recently, a study has shown that in very hot weather, PCBs (if they are present at high levels) can evaporate in small amounts from the soil into the air.[xxi] Nevertheless, current studies of the ambient environments, such as the air in homes, have found no evidence that low-to-moderate PCB concentration levels volatilize.

Human Ingestion of PCBs

The average American, who has had no workplace exposure to PCBs, has a PCB level of 4 to 8ng/ml (parts per billion) in his/her blood. "Over the years, PCBs were so widely used and so carelessly discarded by industry that traces are now found in almost every human on earth," (Sunday Series, Berkshire Eagle, 3/26/95). Once a human or animal ingests PCBs, they are stored in body fat and are also measurable in blood and breast milk. Unfortunately, once the ingestion of PCBs ceases, the PCBs only dissipate very slowly.

According to the EPA, there are three means by which humans can ingest PCBs: consumption of fish or other animals living in a PCB contaminated water environment;

ingestion or inhalation of PCB contaminated dirt; and dermal absorption of PCBs during prolonged exposure to contaminated soils and sediments.[xxii]

The first means of ingestion is through the consumption of fish, waterfowl, turtles, frogs, etc. that live in the Housatonic River, Silver Lake, or any other PCB contaminated habitat. “In 1982, the DEP sampled fish from a 70-mile stretch of the [Housatonic] river, and found elevated levels of PCBs in their blood, prompting an advisory against eating fish from the river,” (Ellen G. Lahr, Berkshire Eagle, 5/9/96). Early in 1998, the U.S. EPA New England office completed human health risk evaluations for the first two-mile stretch of the Housatonic River downstream from the GE facility, an area where there is a widespread prevalence and high concentration of PCBs. They found that “fish collected in the river have PCB concentrations of up to 206 ppm, among the highest levels ever found in the United States and 100 times higher than the limits set by the U.S. Food and Drug Administration,” (www.epa.gov/ region01/ge /pcbshealthandenviro/gehealth.html). As a result, the EPA and GE have posted warning signs along the contaminated bodies of water (Housatonic River, Woods Pond, Silver Lake and Unkamet Brook) limiting fishing to catch and release.

The second means of ingestion is the inhalation of PCBs. Fine dry soil with attached PCBs can be blown by the wind or stirred up while lawn mowing or dirt biking. As noted earlier, PCBs volatilize under certain, infrequent conditions and might potentially seep up from the ground (fill) into people’s homes, although there is not evidence in support of this notion. Furthermore, PCBs in air measured to date in residential and recreational areas do not pose a short or long term health risk.[xxiii]

The third means of ingestion, incidental absorption, includes skin contact and hand-to-mouth contact. Exposure comes from touching soils and absorbing the PCBs through your skin or by touching your dirty hands to your mouth. Children playing along the river or adults working in the PCB contaminated gardens are good examples of contact situations.

Scientific Studies on the Health Effects of PCBs

Several studies detailed below provide a good example of information and uncertainties that help form risk perceptions. As shown in Part I, these perceptions of current and future health risks can be capitalized into house values.

In 1977, the EPA determined that PCBs were probable carcinogens and banned their use. Yet since 1936, public health officials and the PCB manufacturing companies have been discussing the potential dangers of PCBs. Louis Schwarz, M.D. wrote an article in 1936, entitled "Dermatitis from Synthetic Resins and Waxes" which discussed the symptoms of the workers in the PCB manufacturing plants. The workers experienced skin problems such as skin lesions, bad acne, and clogged hair follicles. Interaction with the PCBs also caused "digestive disturbances, burning of the eyes, impotence, and hematuria [the presence of blood in the urine]… The contact of Inerteen [another type of PCB] with the skin causes dryness of the skin, thickening and scaling, and it appears that sufficient quantities may be absorbed in this way to cause damage of the liver," (www.housatonic-river.com/hri_community.html). It is important to note that the skin problems and irritation to the nose and lungs mentioned above are the result of high levels of PCBs in workplaces, which are much higher than PCB concentrations generally found in the environment.

Since the 1930s, a variety of studies have been done on the effects of PCBs on human health. As with any hazardous chemical exposure, the type and extent of illness depends on the length of exposure, the concentration, and the toxicity of the specific chemical, or PCB, in question. It is not uncommon that the research shows a link between PCB exposure and serious illnesses in humans, but many studies on humans have been unable to directly measure the amount (time) and concentration of PCB exposure.

In various studies on humans and animals, PCBs have been shown to produce a wide variety of effects including severe skin problems, liver cancer, liver damage, and reproductive and developmental effects. Monkeys have developed immunological and neurological effects in addition to the above mentioned health problems.

During a 1995 Symposium at the International School of Ethnology in Erice, Sicily, Italy, a group of researchers declared that endocrine (hormone) disrupters can undermine neurological and behavioral development in fish, animals and fetuses. In other words, organochlorines such as PCBs (even in tiny concentrations) can mimic the body's natural hormones and garble, or disrupt, the body's internal message system. The researchers further maintain that many people have ingested enough hormone disrupters (like PCBs) to trigger disease-producing effects. These effects are typically expressed as diminished intellectual capacity or behavioral problems,[xxiv] in addition to "reproductive problems such as decreased sperm counts and increased rates of breast and testicular cancer," (Berkshire Eagle 5/30/96).

Taking the concept of hormone disrupters a step further, a pair of researchers, Joseph and Sandra Jacobson studied the development of children born to women who had eaten PCB contaminated fish from Lake Michigan before becoming pregnant. The PCBs were stored in the mother's body fat and during pregnancy the fat and PCBs were released and passed to the fetus, through the umbilical cord, in response to the fetus' energy demands. Although, at the time of birth, the amount of PCBs in the mother's blood serum and breast milk was only slightly higher than that found in the general population, the newborn children still suffered developmental problems. As a result, those children with prenatal PCB exposure, had "significantly lower general and verbal IQ scores than would otherwise have been expected," (Jane E. Brody, Berkshire Eagle, 9/12/96), in addition to exhibiting poor reading comprehension, memory problems and difficulty paying attention.

Cancer rates in the Berkshire County are normal compared to national averages, yet Massachusetts has selected Berkshire County as an ideal environment for studying household exposure to PCBs in relation to their blood PCB levels. Researchers focused on 800 households that located within a half-mile from the Housatonic River, even though the researchers maintain that the individuals at greatest risk to have high PCB blood levels are those "who worked with PCBs at GE, at other industries or on farms, and people who ate a lot of fish from the Housatonic River," (Sunday Series, Berkshire Eagle 3/26/95).

The EPA conducted a risk evaluation of short-term PCB exposures (less than ten years) in association with the Housatonic River and areas around the GE complex. The area of highest risk is the first two miles of the river south of the GE complex. "The study assumed exposure to PCB-contaminated sediments and soils when residents were walking, playing and sitting in and alongside the river. The exposure is primarily through skin contact with PCB contaminated soil and sediments, and incidental ingestion of dust," (www.epa.gov/region01/ge/pcbshealthandenviro/gehealth.html).

The portion of the Housatonic River between the Newell St.[7], Dawes Ave., and Elm St. Bridges is a serious area of concern. A young child playing for just one summer in the river faces noncancer[8] risks of 200 times higher than the hazard-index level considered safe by the EPA.[9] Older children, assuming springtime and summertime exposure to PCB-contaminated riverbank soils and floodplain soils, face noncancer risk from 90 to 200 times higher than the hazard-index level considered safe by the EPA.

"A nine-year old child who consumes one meal of fish from the Housatonic River each week for just one summer faces noncancer risks about 900 times higher than the hazard-index level considered safe by the EPA," (www.epa.gov /region01/ge/ pcbshealthandenviro/gehealth.html).

In the category of cancer risks, the EPA provides one statistic. A teenager who grows up alongside the river in the vicinity of the above mentioned area, faces a 1 in a 1,000 cancer risk due to their exposure to contaminated river bank soils.

In 1977, the Federal government defined PCBs as a probable cancer-causing agent, although this link between PCBs and cancer in humans has not been firmly established. Scientists believe that PCBs can act as a promoter that may not cause cancer by itself, but in combination with other chemicals (initiators), the promoter can act as a catalyst, spurring on the development of a cancerous tumor. This theory may explain

[7] Newell St. and Lyman St. can be located on the bottom left portion of Figure 6.
[8] Non-cancer risks include digestive disturbances, burning eyes, liver problems, reproductive and developmental problems, and skin problems.
[9] The safe hazard level can be considered the number of people per 100,000 nation-wide that naturally acquire this malady. Thus, if a child played in the river, that incidence in the population would be 200 times higher than the natural incidence. The ambiguity in these statistics should be considered with suspicion, although they do produce some baseline reference for non-cancer risks.

why two plants using PCBs but different subsidiary chemicals reveal vastly different cancer levels among workers.[xxv]

On the other hand, "PCBs have been found to cause liver tumors in laboratory animals, and they have been shown to cause certain kinds of liver ailments, immunological problems, heart problems and skin disorders in humans, according to DPH," (Ellen G Lahr, Berkshire Eagle, 8/20/97).

Case Specific Externalities and their Capitalization in the Pittsfield Real Estate Market

The evaluation of the effects of PCB contamination on the residential housing market in Pittsfield is important because it allows us to begin estimating the social loss created by the negative externalities associated with the GE complex. Substituting General Electric in for the generic industry in Figure 1, one should note that the costs of the PCB contamination are not included in the GE marginal private cost curve. This is so because there are no market or government mechanisms, such as *certain* property rights or pollution taxes, which require compensation for the PCB contamination. For example, no one owns the Housatonic River into which General Electric had released hundreds of thousands of pounds of PCBs, now contaminating the soils and water (a flaw in the Riparian rights system, which is supposed to protect individual water users from the behavior of other users). Consequently, no one is able to collect compensation for the damages to water cleanliness and fish and waterfowl habitat, and the burden falls on those individuals who cannot enjoy the river for recreation purposes.

There are other externalities to be considered, such as the general unsightliness of the GE complex and the current and future health risks associated with contact with the PCBs. Additional property contamination externalities are also very important in an individual's risk perceptions, but unfortunately we were unable to include these in the models because of a lack of data. For example, the possibility that there is a contaminated residential property next door or in the neighborhood, a contaminated neighborhood park, or that the property itself might be contaminated, are all very real issues in the Pittsfield real estate market.[10]

As discussed in Part I, the risk perceptions of perspective homebuyers will be capitalized in a home's value, because bids will be discounted according to the externality-based reduction of future benefits associated with that home. In the case of Pittsfield, a prospective homebuyer might take note of the proximity to the GE complex and include the associated current and future health risks into his/her evaluation. Approached differently, the amount of discount on the real estate bid is the dollar amount of compensation necessary for the prospective buyer to put himself/herself in harm's way, near the PCB contamination.

The value differentials that arise from this data will show the portion of the externalities that have been capitalized into the value of a home. The real estate markets may not include certain losses to society, such as a safe access to river resources and other recreation damaged by PCB contamination. These specific benefits are included only in cases in which the recreational amenities are close enough to the home on the market that the potential homebuyers will directly consider these recreational

[10] While the information is not offered outfront, a prospective buyer can inquire about the presence of PCB contaminated fill on a property and have the soil tested if desired.

(dis)amenities in their bid. Nor will the real estate market include negative externalities to redevelopment that will be discussed later in the section on brownfield redevelopment.

Part III

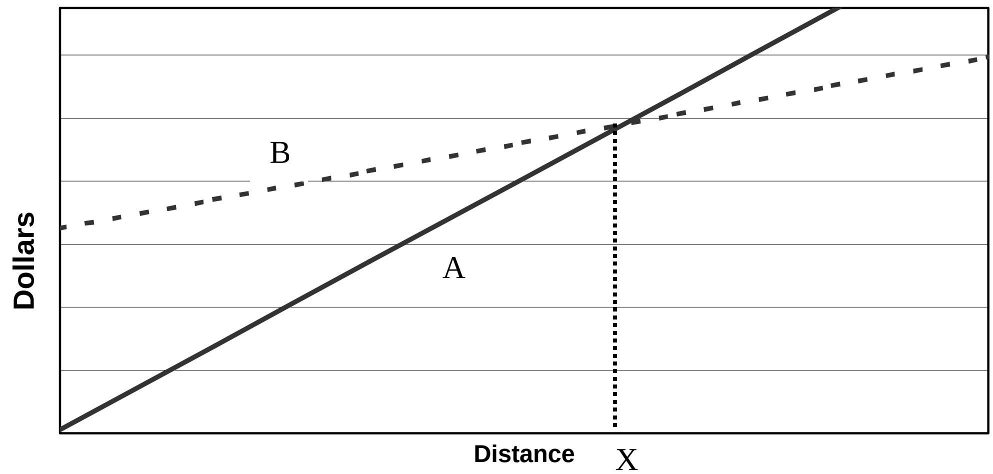
Introduction

An important goal of this research is to provide an evaluation of the costs of PCB contamination in Pittsfield, and the potential net benefits of cleanup efforts. With a hedonic model we cannot necessarily capture all of the costs borne by society as a result of the PCB contamination, but it is possible to obtain a base line of damages. With this basis for measurement we will discuss questions about the sensibility of cleanup and its alternatives.

The hedonic model can be used to measure this base line impact of the PCB contamination. As a preliminary example, we create a function that shows the change in a house's value as a function of distance from an industrial site. The further the home is away from the site, the higher the value will be with all other house characteristics held constant (see Line B in Figure 8). When we include previously unknown information about hazards associated with the site, the distance-value relationship changes such that an additional unit of distance increases the value by a new amount (typically larger than that before the information) as a result of the increased disamenity of proximity to the site (see Line A in Figure 8).

Comparing the value changes before and after the market becomes aware of a hazard, we can determine the maximum extent of the negative value impact. In Figure 8, we see that the height between the before and after curves represents the damage for a typical house at that given distance. At X, the height between the before and after curves, falls to zero. At this intersection, there no longer exist value damages to property, thus signaling the maximum extent of the damages. We can then calculate the total damage of all houses in Pittsfield using this damage-distance relationship.

Figure 8:
Extent and Measurement of Damage



In providing this cost analysis of the PCB contamination, we must carefully examine the dynamic structure of these costs and the process of information dissemination. We begin our analysis with an examination of the role that information dissemination has in our models.

Many economic analyses have implicitly assumed that information is transmitted instantaneously to the whole market. Naturally, economists understand that this assumption is not always satisfied and that there are most likely two timelags: an individual's absorption of the information and the capitalization of this knowledge into market transactions. If we were to assume instantaneous transmission, the entire town of Pittsfield would be fully aware of the full extent of the contamination when the first article appeared in the local newspapers about General Electric and PCBs. However, the results reported below suggest this assumption is unwarranted.

Contrary to this assumption, as noted earlier in Part I, an individual's perception of risks may be thought of as evolving through a process of Bayesian Learning, in which prior assessments of potential losses and their variability are *updated* with new information. This information may come from the EPA and the Berkshire Eagle, Pittsfield's main newspaper, for example. The Berkshire Eagle, based in Pittsfield, is the main source of news for Pittsfield and Berkshire residents with a daily circulation of 31,037 and a Sunday circulation of 35,572, in 1997.[11] With current circulation numbers slightly higher in 2001, the Berkshire Eagle is the most widely read newspaper in the city. The Berkshire Eagle has played a key role in the dynamic process of informing the Pittsfield residents about the PCB contamination, its severity, and the associated health risks. Their perceptions have been continually updated through a slow accretive process in which each Berkshire Eagle article has contributed to their general knowledge of the PCB issues.

The Superfund announcement has also played a very important although possibly ambiguous role in the residents' interpretation of current and future risks. Some may see a NPL declaration as a verification of the severity of the pollution and risks, while others might interpret the announcement as a positive sign of future cleanup. Regardless of whether the announcement is seen as a positive or as a negative signal for the future, the Superfund issue has heightened the residents' sensitivity to PCB related issues and articles.

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[11] This can be compared with the rough count of 140,000 residents and 60,000 households in Berkshire County.

Why is it important to study information transmission?[12] First, this issue of information transmission is not specific to the case of Pittsfield. It touches every realm of economics in which a consumer bases purchase decisions on various sources of information. Second, it helps us better understand how sales patterns are affected as a function of information. Third, we can make inferences about the processes of absorption and assimilation of information that impact the market.

The following analysis will show two mechanisms by which the PCB information was disseminated into the market and how the gradual changes in the population's knowledge pervaded and affected property values. As a result of this analysis, we will be able to explore the costs of the PCB contamination and thereby the benefits of cleanup. Focusing on the case in Pittsfield, we can make specific comparisons of the expected benefits of cleanup and the costs endured in the process. Finally, we will apply an analysis of the net benefits related to the PCB cleanup efforts.

Data

We estimate the hedonic price function using observed house prices adjusted for inflation, as a function of the structural, neighborhood, and location variables of the property. The structural characteristics include things such as the number of bathrooms and square feet of living space. The neighborhood variables include elementary school MCAS scores and ethnic make-up of the census block. The location variables include

[12] There are no known studies that examine the speed of information transmission, nor have any studies noted the differences in market effects as a result of using the assumed instantaneous transmission versus another timing of transmission

distance to the General Electric complex and distance to downtown Pittsfield.[13] Variables on the amount of publicity and the Superfund announcement are included in the hedonic model to measure the effect of information dissemination, such as the Superfund announcement and newspaper articles, on property values.

Data on individual house sales in Pittsfield ranging from February 1, 1996 to October 31, 2000 provide the basis for the analysis. The sales data were provided by a Multiple Listing Service (MLS), courtesy of the Berkshire Board of Realtors. The sales price has been adjusted with a CPI[14] index so that results will be measured in constant dollars.

This housing data is augmented by school catchment information provided by the local school bus service. This information is combined with the elementary school MCAS[15] scores that help assign a quality of schools and neighborhood. The MCAS (Massachusetts Comprehensive Assessment System) tests are administered to students in grades four, eight, and ten and are used to measure how well students, schools, and districts are achieving the academic learning standards that have been determined by the state. Census information was used to calculate the percentage of white residents in the neighborhood, made possible with GIS software that linked each home to the appropriate census tract.[16]

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[13] Distance to Downtown Pittsfield is included for two reasons: (1) it is an important part of estimating a house's value because people value proximity to shopping and employment centers. (2) Because downtown Pittsfield and the GE complex are so close to each other (1 km) it is necessary to separate out these effects to conduct an accurate analysis.

[14] We used the non-seasonally adjusted CPI index for the U.S. City Average, 1982-4=100 (base year).

[15] The MCAS scores were calculated as the average of the average scaled scores for the English Language Arts, Mathematics, and Science & Technology tests. An average was also taken over the two or three years that the MCAS scores were recorded.

[16] We also examined the effects of vacant homes and education achievement on property values, but there were no significant results.

The MapInfo Geographic Information System (GIS) was used to determine the longitude and latitude coordinates of each house, a spot on the GE complex, and the center of downtown Pittsfield[17]. With each coordinate pair, we calculated the distances from each house to each "location". Buffers were also created around the entire GE complex so that we could compare the effects of distance from the plant in general as an overall risk and eyesore as compared to the risk of a certain hotspot within the plant area.

A dichotomous variable is constructed to identify the time periods before and after EPA administrator John DiVillars' August 4, 1997 announcement of his nomination of the GE/Pittsfield complex and the Housatonic River for placement on the National Priorities List (NPL) of Superfund, i.e. naming the area a "Superfund site". To create the dummy variable and to adjust for a lag in real estate market adjustment and individual perceptions, we pushed the Superfund cutoff back to August 15, 1997. A variety of cutoff dates were tested and August 15 provides the best fit with the model.[18] All sales before or on this date have "0" as the dummy variable and all sales after are "1".

In theory, the Superfund announcement should help Pittsfield residents solidify what they have been hearing about PCB contamination, thus better forming their risk perceptions and better penetrating the real estate market. It is also reasonable to consider that the Superfund announcement heightened individuals' sensitivity to future information from Berkshire Eagle articles. The Superfund variable itself represents the base change in value of a Pittsfield home resulting from the Superfund announcement. It can also be interpreted as the change in value of a home zero kilometers, or units, from

[17] Downtown Pittsfield is located on Figure 10 with a little black obelisk.
[18] In relation to this, there has also been confusion about the length of time between the sales agreement and the sale's closing date recorded in the data. Regardless, August 15 performed the best in the model, which suggests that it best represents the real world behavior of Superfund based perception changes.

the GE complex. As a result, the full devaluation is a function of this primary devaluation plus an additional devaluation based on distance from the GE complex. See Figures 9-11 for home locations.

The second information variable is a time-lagged average of the number of PCB articles per month in the Berkshire Eagle during the three months previous to the date of sale. We searched the Berkshire Eagle archives for all articles with the word PCBs. The headlines for each article were read for level of connection with the PCBs in Pittsfield. For example, election platforms and results that might mention PCBs as an afterthought are not included in the count, nor are editorials or letters to the editor. The publicity variable is the average number of articles written about PCBs associated with Berkshire County within the three months before the sale of the house. This variable is interacted with the Superfund dummy as well as the inverse of distance to GE, thus providing a range of impact for each article based on time and a home's location.

We chose Berkshire Eagle newspaper articles as a measure of information dissemination because it has easily accessible archives that enabled us to search their indices for PCB related articles. While TV news and word of mouth are other important vehicles for information dissemination, it is reasonable to assume that the number of newspaper articles is highly correlated with any means of information flow. For example, if there is an increase one month in the number of Berkshire Eagle newspaper articles, there would very likely be more TV news coverage and as a result more discussion among residents.

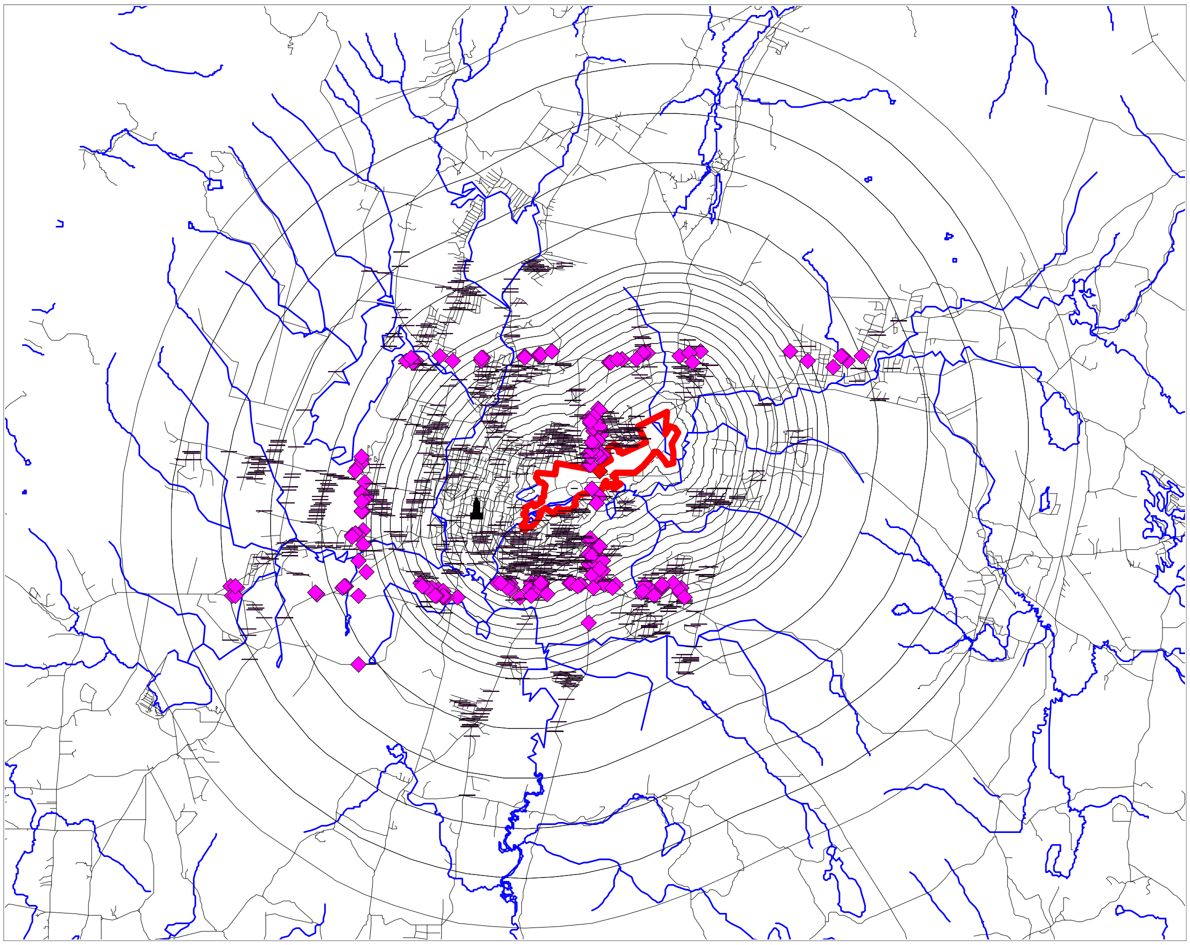


Figure 9: Houses Sold After the
Superfund Announcement

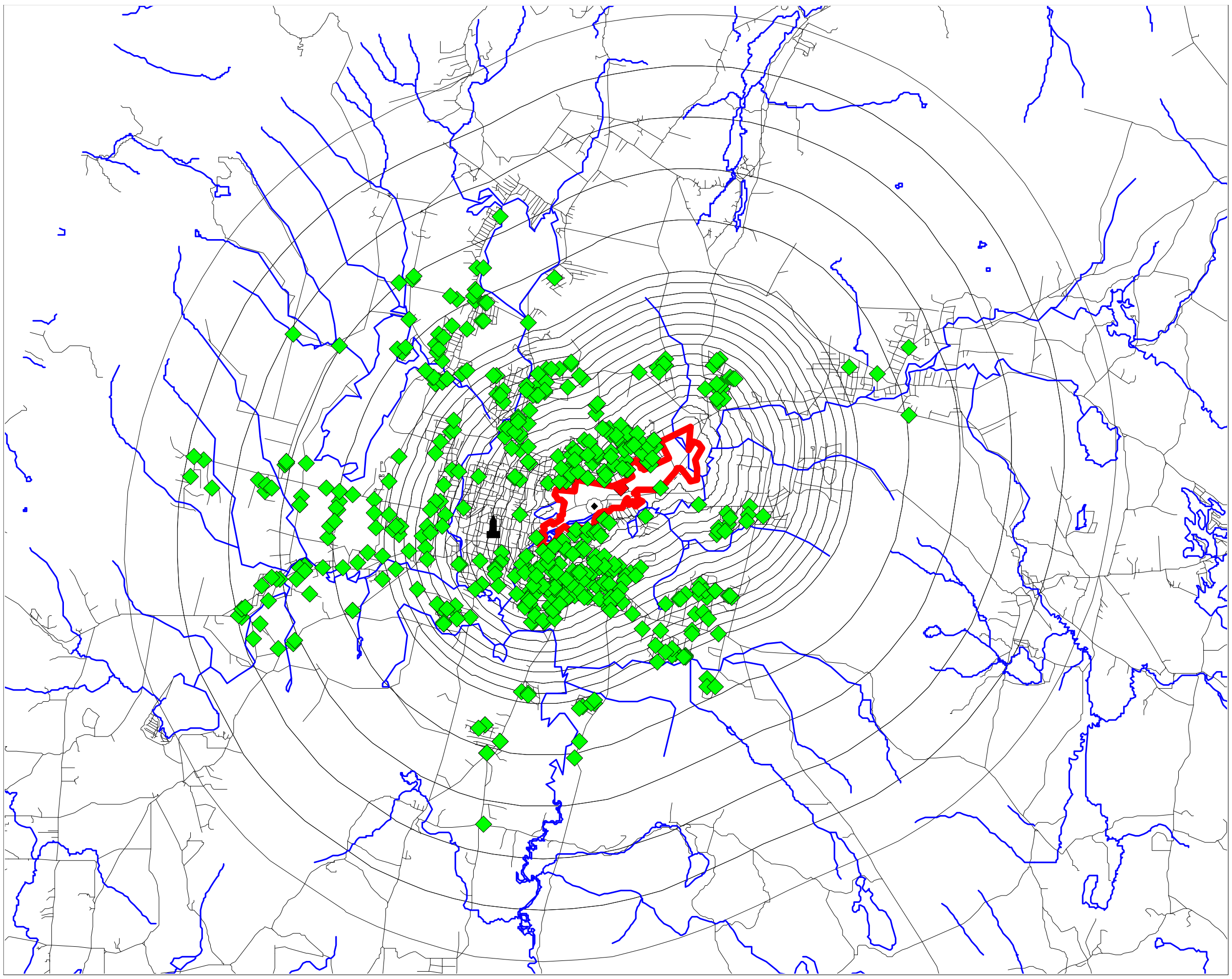


Figure 10: Houses Sold Before the
Superfund Announcement

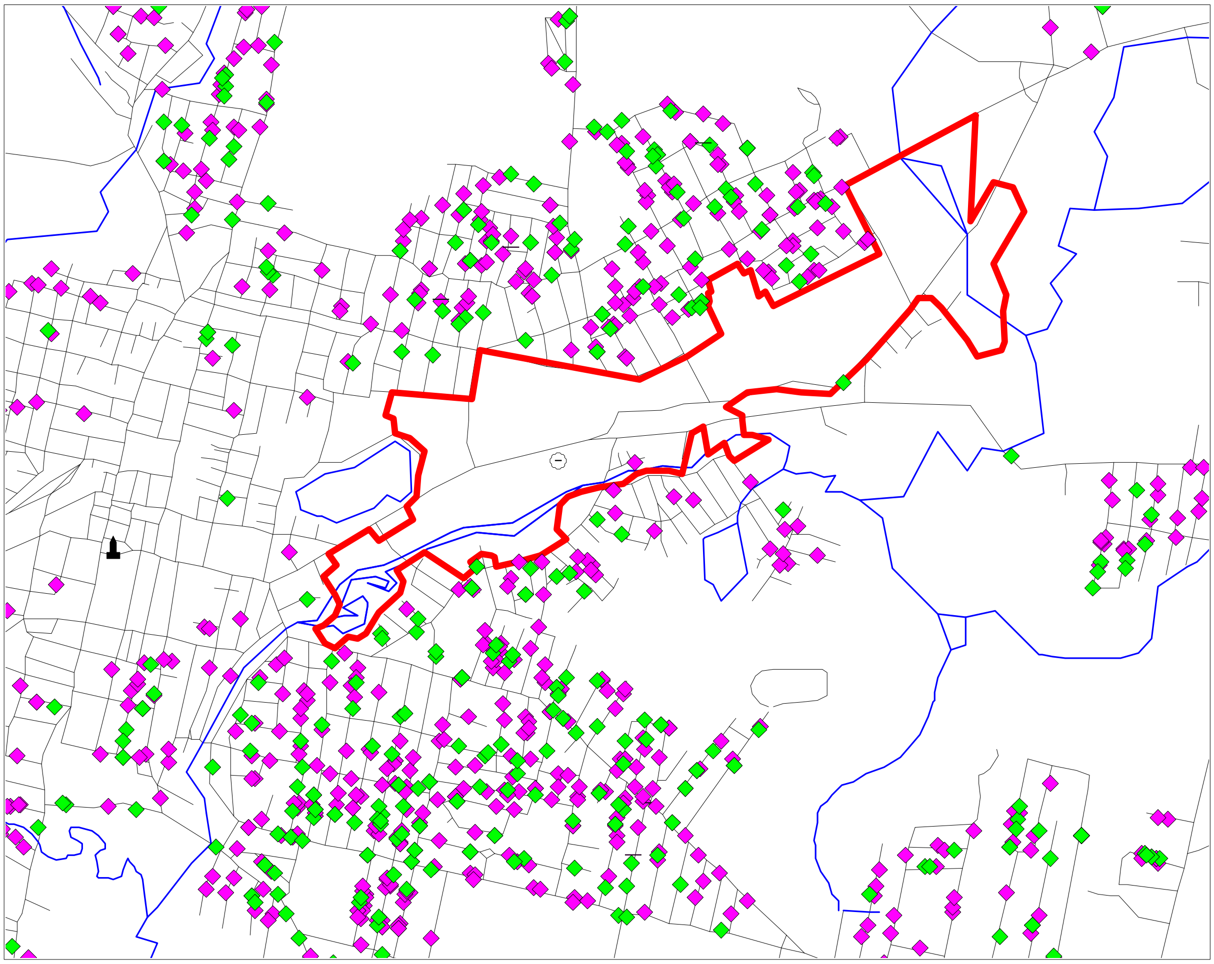
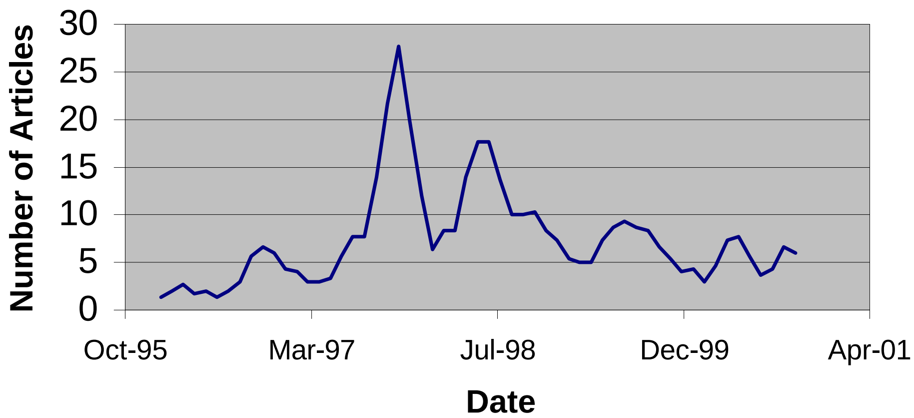


Figure 11: Close up detail of houses around the GE complex. The houses sold before the Superfund announcement are green and those sold after are magenta.

Figure 12 shows the average number of articles for the three months prior to the labeled month. The averages vary from 1.3 to 27.6 with an average of over ten articles per month sustained from September 1997 to November 1998.

Figure12:
Average Number of Articles for Prior Three Months



See appendix for more variable descriptions.

Figures 9-11 show the spatial distribution of homes in our data sample. The homes sold before the Superfund announcement are marked by green diamonds and those sold after are marked by magenta diamonds. In these maps, the General Electric complex and adjacent contaminated areas are bordered by red. The concentric oval shapes are the buffer zones. Beginning adjacent to the site, the buffer intervals are spaced 200 meters apart for the first 3,000 meters. At a distance of 3,000 meters from the site, the buffer intervals change to 1,000 meters each with the final buffer delineating 8,000 meters from the edge of the GE complex.

Table 1 depicts the characteristics of the mean house of our sample of 1,372 houses. The typical house in our sample, sold on the market from 1996-2000, has a mean value of $72,317. It is 2.99 kilometers from downtown Pittsfield and 2.92 kilometers from a fixed point on the GE complex and 2.22 kilometers from the edge of the complex as a whole. The typical home has 17,984 square feet of land, or 0.41 acres, and 1,603 square feet of living space. The mean house has three bedrooms, one and a half baths, and one fireplace. The average house is 56 years old and the neighborhood is 97.6% white. The typical elementary school MCAS score is 236.7.

Table 1: Summary of Variables

	Mean	Std. Dev.	Minimum	Maximum
Indexed Price	72317	43700	5573	431035
Distance to Center	2.99	1.40	.302	9.23
Distance to GE (Point)	2.918	1.59	.280	7.82
Distance to GE (Buffer)	2.22	1.67	.2	7
Distance (Point) of Houses Sold Before Superfund	.728	1.48	0	7.82
Distance (Point) of Houses Sold After Superfund	2.19	1.88	0	7.82
Sq. Ft. Land	17984	43573	532	993621
Sq. Ft. Live	1603	737	121	12315
No. of Bedrooms	3.20	0.94	1	20
No. of Bathrooms	1.643	0.738	0.2	9
No. of Fireplaces	0.544	0.65	0	5
Age of House	55.6	30.87	0	220
4^{th} Grade MCAS	236.87	5.70	225	243.7
% White residents in Census Block	97.62	3.23	65.3	100

Empirical Results

Our real estate market model decomposes the price of a house into components attributable to neighborhood and house characteristics. Controlling for these characteristics allows us to explore the effect of proximity to things such as Downtown Pittsfield and the General Electric Complex. In addition, different information dissemination variables have been interacted with distance to the GE complex.

For all the models, an important first test is to check that the house and neighborhood variables are correctly signed and the magnitude makes sense. A priori expectations are that coefficients for the structural characteristics will be positive except for age and age squared, expectations that are consistent with our regression results.

Using information from Model 1 in Table 2, we interpret the coefficients in such a way that a unit increase in X, the number of bathrooms for example, will increase Y, the value of a home, by the magnitude of the coefficient.

Table 2: Model 1, Distance to a Point in the GE Complex

Value of the Home

Explanatory Variables	Coefficient	T-stat
Distance to GE (Point)	2203	(4.302)
Distance to Center	-220.78	(-0.386)
Sq.Ft.Land	0.105	(7.894)
Sq.Ft. Live	35.414	(23.345)
Baths	5288	(3.95)
Fireplaces	3743	(3.56)
Age	-287	(-4.503)
Age Sq.	0.0353	(0.091)
Ranch	1428	(0.891)
Colonial	791	(0.525)
Mobile	-40854	(-5.041)
Contemporary	28436	(8.037)
Garage	5604	(3.9)
Natural Gas	3911	(1.64)
Oil	2677	(1.11)
Propane	1131	(0.195)
MCAS	732.4	(6.371)
Ethnic	658	(3.59)
Constant	-233492	
R-Squared	0.7572	
Adjusted R-Sq.	0.754	

We see that an extra square foot of property adds \$0.10 to a home, or acre of land adds \$4573.80 to the value of a house. An elementary school with an additional MCAS point increases the house value by $732.40. An additional bathroom increases a house's value by $5288 and each year of a home's age decreases the value of a house by $287.

A final note about interpreting the models is that the t-stats measure the significance of a variable. For example, a t-stat with an absolute value larger than two means that that variable's coefficient is significantly different from zero.

It is instructive to examine several versions of the hedonic model. Our first model measures distance from one point within the GE facility[19], an area that is heavily polluted, to create a variable to indicate the exposure to environmental hazard. We find that proximity to this point decreases the value of homes (see Table 2 Model 1). We interpret this variable's (Distance to GE [point]) coefficient as the increase in value of a typical house per kilometer of distance from the GE complex. However, this distance/value relationship is not very intuitive because we would expect that this value effect would diminish with distance. This problem will be addressed in Model 4.

This point within the GE complex was chosen as a preliminary test for simplicity, recognizing that an analysis based on a single point, within the GE complex, would be misleading for a variety of reasons. First, it is possible that individuals might not focus on this point but rather on the complex as a whole. While they might recognize this portion as highly polluted, they will make their choices based on an overall ambience of pollution associated with the entire complex. Looking to the map of the GE complex (Figure 7), we see this heavily polluted area on the western half of the site, yet on the eastern portion there are the heavily polluted Unkamet Brook and the municipal landfill with buried PCB-waste barrels and other contaminants. It is not unreasonable to

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[19] In figure 9, the circle with a dot in the middle represents this point in the GE site. Please refer to figure 7 to see the contamination plumes located with this portion of the site.

uniformly spread this ambience of pollution over the entire 254-acre site. Second, a resident will measure their proximity to the GE complex as a straight line from their house to the edge of the complex. By doing so, this gives a consistent measure of proximity that is not weighted by our off-center point.

This model with distance to GE measured with buffers is shown in Table 3, Model 2. Again, we interpret the Distance to GE (Buffer) coefficient as the increase in a home's value per unit of distance from the GE complex.

Table 3: Model 2 Distance to GE (Buffers)

Value of the Home Explanatory Variables	Coefficient	T-stat
Distance to GE (Buffer)	2152.8	(4.67)
Distance to Center	8.637	(0.016)
Sq.Ft.Land	0.104	(7.83)
Sq.Ft. Live	35.44	(23.39)
Baths	5365	(4.02)
Fireplaces	3791	(3.61)
Age	-269.9	(-4.221)
Age Sq.	-0.0299	(-0.077)
Ranch	1641	(1.025)
Colonial	878	(0.583)
Mobile	-41844	(-5.161)
Contemporary	28158	(7.957)
Garage	5661	(3.948)
Natural Gas	4050	(1.696)
Oil	2747	(1.14)
Propane	846.7	(0.146)
MCAS	740.8	(6.473)
Ethnic	612	(3.34)
Constant	-231078	
R-Squared	0.7578	
Adjusted R-Sq.	0.7546	

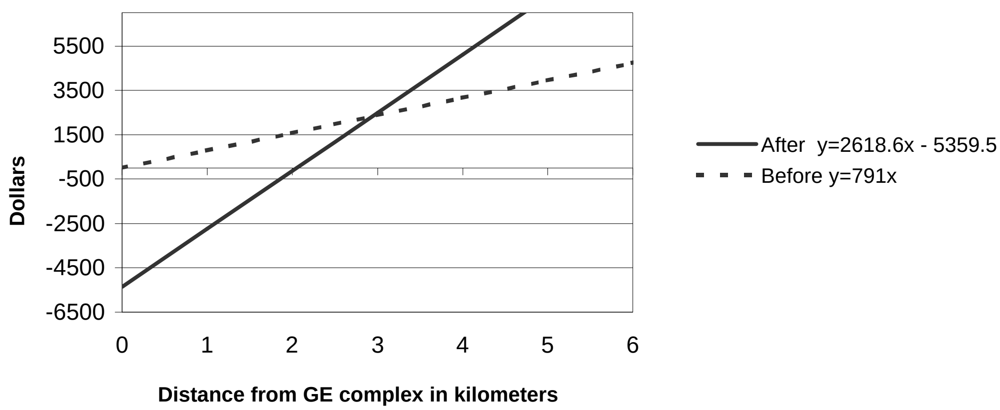
Our next model shown in Table 4, Model 3, includes a variable that interacts the Superfund announcement dummy variable (before and after the date) with distance to GE (Buffer). This model variation illustrates two important points of information dissemination and externalities. First, the primary intention, is to measure how the impact on house values of distance to the GE complex differs based on the Superfund announcement of August 4, 1997. In theory, this announcement should help Pittsfield residents solidify what they have been hearing about PCB contamination, thus better forming their risk perceptions and better penetrating the real estate market. Second, this variable helps separate out the effects of the various externalities. For example, before the Superfund announcement, it can be argued that the majority of the effect on value was due to visual blight, and that after the Superfund announcement, the effect is substantially increased due to knowledge of the PCB contamination and perhaps the "Superfund stigma".

Table 4: Model 3: Distance to GE (Buffer) Interacted with Superfund Dummy

Value of the Home Explanatory Variables	Coefficients	T-stats
Distance to GE (Buffer) After Superfund	2618.6	(5.2)
Distance to GE (Buffer) Before Superfund	791	(1.05)
Superfund Dummy	-5359.5	(-2.53)
Distance to Center	17.9	(0.034)
Sq.Ft.Land	0.11	(7.94)
Sq.Ft. Live	35.4	(23.4)
Baths	5246	(3.94)
Fireplaces	3828.3	(3.66)
Age	-269.2	(-4.2)
Age Sq.	-0.03	(-0.078)
Ranch	1729	(1.1)
Colonial	973.5	(0.65)
Mobile	-41635	(-5.14)
Contemporary	27775	(7.82)
Garage	5758	(4.02)
Natural Gas	3962.9	(1.65)
Oil	2690	(1.11)
Propane	928.7	(0.16)
MCAS	730.3	(6.38)
Ethnic	615.6	(3.36)
Constant	-224968.9	
R-Squared	0.759	
Adjusted R-Sq.	0.7554	

Comparing the value changes before and after the Superfund announcement with information from Model 3, Figure 13 shows that within the first 2.93 km, there is a negative effect on property values as a function of proximity. As we move beyond this point however, the graph suggests that houses increase in value or rather a premium is placed on homes beyond 2.93 km from the GE complex.

Figure 13:
Extent and Measurement of Damage



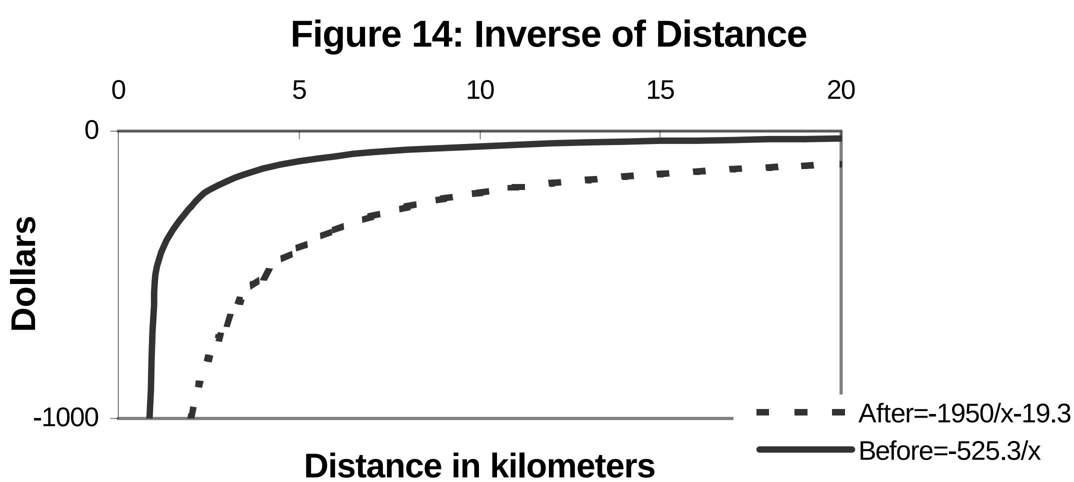
Janet Kolhhase, as noted in the Literature Review, described this premium as the result of a market for “safe-housing”. It is possible that a large movement of individuals selling homes near the GE complex and buying other homes further away could increase the demand for distant homes and thus inflate the value of these homes. In this scenario, one must note that within 3km, there is a loss to society in terms of house values. Yet, the premium for “safe-housing” beyond 3km, or rather the increase in distant homes’ value should not be considered a benefit of the distance/value relationship, but rather a side effect.

Now assuming that a premium is not placed on these homes, we have created a model, shown in Table 5, in which we have multiplied the Superfund dummy by the *inverse* of distance to eliminate this possibility. Furthermore, the inverse of distance facilitates the correct interpretation of value change as a function of distance, where there is a diminishing impact on value with distance. We interpret this coefficient as the effect of increasing 1/distance in km by one unit. Increasing this variable by one unit would require, for example, moving from 1km to 0.5km from the GE complex.

Table 5: Model 4: Inverse of Distance to GE (Buffer) Interacted with Superfund Dummy

Value of the Home Explanatory Variables	Coefficients	T-stats
Inverse of Distance to GE (Buffer) After Superfund	-1950	(-3.17)
Inverse of Distance to GE (Buffer) Before Superfund	-526	(-0.478)
Superfund Dummy	19.3	(0.011)
Distance to Center	843.8	(1.715)
Sq.Ft.Land	0.11	(8.31)
Sq.Ft. Live	35.55	(23.35)
Baths	5661	(4.231)
Fireplaces	3771	(3.558)
Age	-280	(-4.351)
Age Sq.	0.0296	(0.076)
Ranch	1521	(0.944)
Colonial	734	(0.485)
Mobile	-39560	(-4.869)
Contemporary	29763	(8.39)
Garage	5742	(3.978)
Natural Gas	3734	(1.547)
Oil	2405	(0.99)
Propane	1480	(0.254)
MCAS	628	(5.64)
Ethnic	705	(3.808)
Constant	-209970	
R-Squared	0.7559	
Adjusted R-Sq.	0.7523	

The following figure shows this new relationship. While it does not provide a cutoff for the extent of property value impact, it does accurately show the damage as a function of distance without creating a premium in houses over 2.93 km from the GE facility.



Models with Newspapers as a Measure of Information Flow

Models 5-7 in Table 6, take the concept of information dissemination a step further. These models interact the Superfund dummy and the inverse of distance to GE, with a number of Berkshire Eagle articles related to PCBs for the three months prior to the sales date of a home. The following model coefficients show the effect of an additional Berkshire Eagle article on a house 1 km away from the GE complex, or the effect of increasing 1/distancekm by one unit when there is one article. This model is particularly interesting because it can illustrate how information dissemination is not instantaneous but rather that information flows are continuous and additive.

The very notion that there are a varying number of articles per month about PCBs and that there is new information in each article supports our claim that information dissemination is not instantaneous. This model can also show that an individual's absorption of information can have real and changing effects on markets.

Pittsfield residents have been aware, to some extent, of the PCB contamination of the GE complex and the Housatonic River since the early 1980s. There have been small PCB cleanups conducted by the EPA, GE, and the DEP, and moreover, there have been fish and wildlife consumption advisories. This basic awareness of the issues was conveyed through Berkshire Eagle newspaper articles, before the Superfund announcement.

Table 6: Models 5-7 Inverse of Distance Interacted with the Publicity Variable

Value of Home Explanatory Variables	[5]	[6]	[7]
	Coefficients with (T-stats)		
Articles*Before Superfund*1/distance	-84.55	85.06	-57.37
	(-0.407)	(0.402)	(-.150)
Articles*After Superfund*1/distance	-154.62	-76.34	-76.93
	(-3.063)	(-1.408)	(-.964)
Distance to Center	956	70.66	861.64
	(1.967)	(0.132)	(1.75)
Distance to GE (Buffer)		1935	
		(3.83)	
Superfund Dummy	-357	-449	24.7
	(-0.223)	(-0.282)	(.014)
Inverse of Distance to GE Before Superfund			-264.05
			(-.131)
Inverse of Distance to GE After Superfund			-1224.53
			(-1.26)
Sq.Ft.Land	0.11	0.104	.11
	(8.33)	(7.85)	(8.31)
Sq.Ft. Live	35.46	35.42	35.5
	(23.28)	(23.37)	(23.3)
Baths	5771	5370	5694.5
	(4.315)	(4.024)	(4.25)
Fireplaces	3933	3752	3799.4
	(3.73)	(3.57)	(3.58)
Age	-283	-264	-278.7
	(-4.4)	(-4.12)	(-4.33)
Age Sq.	0.041	-0.0534	.024
	(0.106)	(-0.137)	(0.061)
Ranch	1585	1694	1540.95
	(0.99)	(1.057)	(.956)
Colonial	821	916.2	756.8
	(0.542)	(1.057)	(.499)
Mobile	-39280	-41737	-39571
	(-4.84)	(-5.148)	(-4.87)
Contemporary	29820	28481	29771
	(8.4)	(8.029)	(8.39)
Garage	5684	5728	5695.3
	(3.93)	(3.98)	(3.94)
Natural Gas	3836	4156.6	3766
	(1.59)	(1.731)	(1.56)
Oil	2537	2822	2452
	(1.04)	(1.166)	(1.0)
Propane	1387	948.7	1414.5
	(0.238)	(0.164)	(.243)
MCAS	605	732.9	625.1
	(5.494)	(6.397)	(5.604)
Ethnic	694	646	707.7
	(3.754)	(3.503)	(3.82)
Constant	-204056	-231860	-209577.3
R-Squared	0.7558	0.7585	0.7561
Adjusted R-Sq.	0.7522	0.7547	0.7521

Model 5, Table 6, shows that there is a noisy relationship between these articles, averaging 3.8 a month, and the effect on property values before the Superfund announcement, as shown by the small t-value. It is not unreasonable to assume that the Pittsfield residents read these articles but that they were not quite sure what the information implied about current and future risks associated with the GE complex. For this reason, the articles do not have a solid and consistent effect in the real estate market, before the Superfund announcement, as demonstrated in the model.

After the Superfund announcement, the number of articles rose to an average of 9.3 articles a month, with as many as 28 articles in a given month. With the hype of the pending Superfund decision, came endless information about PCB related health risks and property contamination rights. As a result of this increased flow of information and the clarification of PCB related risks as signaled by the Superfund announcement, prospective homebuyers most likely took this information into account while calculating a bid for a home. Consequently, the after Superfund publicity coefficient almost doubles (-157.62) and becomes significantly different than zero, as shown by the t-value of –3.063.

As proposed above, this change in significance from before to after the Superfund announcement, suggests that the Superfund announcement played a key role in post August 15, 1997 information dissemination and in the capitalization of the disseminated risks into the real estate market. In other words, the Superfund announcement signaled the severity of the PCB contamination and the associated health risks for Pittsfield residents. This knowledge, broadcasted city-wide by the Superfund hype, created a platform from which the Pittsfield residents could read and interpret the Berkshire Eagle articles, thus better informing their perceptions of the PCB issues and the associated risks. These ever-updated perceptions (ever-updated because of the continual release of new PCB information) are then capitalized into the real estate market by prospective homebuyers, using this risk information in calculating their bid for a home.

For the sake of argument, we include Models 6 and 7 in which we control for a home's proximity to the GE complex in order to separate out the newspaper augmented change in value. In Model 7, we see a classic case of collinearity. We are unable to separate out the effects of the newspapers and distance because these effects are correlated, or rather, they move together. Another way to interpret this matter is that the increased level of newspapers raises the risk awareness of the Pittsfield residents, who in turn capitalize these risks into property bids as a function of distance from the risk. The information dissemination *is* the factor that enables these distance-based price differentials.

Analysis of the Impact of Distance and the Superfund Announcement

The following table uses the sample mean house to calculate the varying effects of proximity to GE as we move the house closer to and further away from the complex. The average house in the model is 2.22 km from the edge of the GE complex and its market value is $72,317 in constant dollars with base year 1982-1984. The mean house value is decreased by $1950.14 (Model 4, Table 5) for each one-unit increase in (1/distance) measured in kilometers from the GE complex. Remember that these variables use the inverse of distance and that is why the coefficients are negative. On the other hand, if we measured a straight distance from GE (Models 1 and 2 in Tables 2 and

3), the variable coefficient would denote the increase in value for an additional kilometer of distance away from the GE complex.

Using the data from Model 4, we calculate the monetary impact of distance on the typical home at three different distances from the GE complex: 2.22 km (the sample mean), 5 km, and 750 meters. Comparing a typical home at 2.22km from the GE complex with a home 750m from the GE complex, we see that this 1.47 km change in distance reduces the value of a home, before the Superfund announcement, by $701, a 1% loss in value. Note: these value and percentage-value changes are based on the sample mean house value, not the impacted value at the sample mean distance. This same relocation of the sample mean house after the Superfund announcement decreases the value by $2619.48, a 3.6% reduction in the value of the home. See Table 7 for more information on these impact estimates.

Table 7: Calculated Impacts on a Sample Mean House Based on Model 4

	750m	2.22km	5km	Mean House Value $72317
Before Superfund	-700.71	-236.73	-105.1	Parameter Values Below
After Superfund	-2619.48	-897.74	-409.33	Superfund 19.3
After % Decrease Value	3.6	1.24	0.57	Before -525.536
				After -1950.135

To put these values in perspective with the number of impacted houses, there are 5,274 homes within 750 meters of the GE complex. The majority of these homes are in the Lakewood and Allendale neighborhoods, just south and north of the complex, respectively. There are 9,906 homes between 750m and 2.2km from the GE complex, and 6,588 homes from 2.22km to 5km from the GE complex. Finally, from 5km to 8km there are 6,656 homes.

It is important to note that in Model 4, the "Inverse of Distance to GE (Buffer) Before Superfund" coefficient shows that Pittsfield residents prefer to live further away from the GE complex, even before the Superfund announcement. A typical house in a neighborhood adjacent to the GE complex is worth $700 less than houses further away from the site, with all other characteristics held constant. This may be because of the noise, traffic, or the ugliness associated with the site. The "Inverse of Distance to GE (Buffer) After Superfund" coefficient becomes almost four times as large as the "Inverse of Distance to GE (Buffer) Before Superfund" coefficient, meaning that the impact of distance is four times as large as before the announcement. This increase in the demand to live further away, or rather, the amount of money an individual requires to live near the plant, must result from the homebuyers' realization of the risks associated with the PCB contamination on the GE complex and in the adjacent portion of the Housatonic River.

We might also consider individuals who own their home prior to when these PCB issues came to light, around 1980, for example. In this case, homeowners who already own the property before the negative externalities become apparent, suffer a capital loss as the external damage is capitalized into the price of their property. To comprehend this issue, we must remember that capitalization damages might occur at a pivotal moment in the media, such as an announcement regarding National Priorities List (NPL) inclusion of a nearby landfill or industrial complex. In addition, these value damages can continue to accrue as more risk information is available and is included in real estate market decisions. Thus, as mentioned above, the information dispersal process is continual and as a result, there may be continual reductions in the value of a home.

The Superfund announcement plays an interesting role in information dissemination and the capitalization of externalities into the real estate market, because EPA announcements send signals to the public about the severity of environmental damage and the potential risks to humans. The pending[20] "Superfund site" status has stirred up a lot of controversy among various groups in Pittsfield as noted earlier in Part II. Furthermore, many are afraid of a potential "Superfund stigma" that could bring down property values throughout Pittsfield regardless of proximity to the GE complex. In addition, the Superfund hype might have made Pittsfield residents more sensitive to discussion of current and future risks through information channels such as, word of mouth, newspaper articles, lawsuits, town meetings, political platforms, etc. In this way, current and future risks are continually communicated to a house-buying public.

Newspaper Article Impacts

Table 8 shows the impact of PCB related newspaper articles on property values as a function of distance from the GE complex. The impacts have been calculated in two ways, using information from Model 5. The first section shows the impact of ten articles[21] on homes at the three given distances, while the second portion shows the impact per article. We see that an additional newspaper article before August 15, 1997

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[20] Throughout the bargaining process, John DeVillars used the Superfund designation as a threat to encourage GE to pay for damages. Therefore, the date was regularly pushed back, thus ever postponing the negotiation cutoff date that would force a decision about the Superfund designation.

[21] The average number of articles after the Superfund announcement is 9.3, so we round up to 10 for simplicity. We use 10 articles for the "before" impact calculation so that we can compare like to like. As Figure 12 shows, the number of articles increases just after the Superfund announcement and the articles range in number from 1.3 to 27.6 per month, or as an average over the prior three months.

(the Superfund announcement) decreased the value of a home by $84.55, and that an additional article after the Superfund announcement decreased the value by $154.60, by almost twice as much.

Table 8: Calculated Impacts on a Sample Mean House Based on Model 5

Ten articles	750m	2.22km	5km	Mean House Value $72317
Before Superfund	-1127.33	-380.86	-169.1	
After Superfund	-2418.13	-1053.2	-666	Parameter Values
After % Decrease Value	3.34	1.56	0.92	Superfund -356.8
				BeforeArticles –84.55
Per article Before	-112.73	-38.09	-16.91	AfterArticles -154.6
Per article After Superfund	-206.13	-69.64	-30.92	

The coefficient for the Superfund dummy itself indicates a base devaluation of homes of $356.80 after the Superfund announcement. In addition, a home 1 km from the GE complex will further decrease in value by $154 for each article. Now assuming an average of 10 articles, Table 8 shows the decrease in value associated with the three distances. Please note that these devaluations are similar to those calculated in Table 7.

A Comparison with other Hedonic Studies

Other hedonic models for pollution hazards show similar results in terms of dollar impact per unit of proximity and the maximum extent of the negative effect. We have been unable to locate any published hedonic models that study the effect of PCBs on real estate and on a community at large, therefore we are unable to make a direct comparison.

To help the reader compare this case's results with the other hedonic studies, we provide a short synopsis. The average house value is $72,317, the Superfund announcement impact on houses ranges from $1950 to $2618 depending on the model, and the percent depreciation of value ranges from 0.3% to3.6%, depending on the model and distance. Using Model 3, we see an estimated maximum extent of value damages at 2.9km, as seen in Figure 13.

Janet Kohlhase's [1991] study of the impact of proximity to toxic waste sites on home values, reveals a maximum extent of negative impact that ranges from 1.86 to 6.19 miles, depending on the specific toxic waste site in question. With an average house price of $101,650, the impact of houses ranged from $1006 to $3310, again depending on the specific site in question. A 1.0% to a 3.3% depreciation in house values.

Nelson, Genereux, and Genereux [1992] find that one Minnesota landfill decreased home values by 12% at the landfill boundary and by 6% at one mile's distance. Beyond 2-2.5 miles away from the landfill, effects are negligible.

Baker's [1988] analysis of the Love Canal disaster found that for the Waterford location "the average house one mile away after Love Canal would have an expected price of $16,400; the same house two miles away would be expected to sell for about $18,000."[22] The Porter location shows similar results. "The typical house one mile away in this case would go for about $38,834 after Love Canal; two miles away, $43,580," (Baker, 1988: 47-55).

Smolen, Moore, and Conway [1992] reaffirm the results once again. Proximity to the Riga hazardous waste landfill has a negative effect on house values such that from 0-2.6 miles from the landfill, houses increase in value by $5,780 per mile moved away. For 2.6-5.75 miles, the house increases in value by $4,160 per mile (Smolen, 1992: 4-11).

Gayer, Hamilton, and Viscusi [2000] were the first to specifically study the effects of information dissemination on real estate markets using a Bayesian Learning model. While our study's results cannot be directly compared to Viscusi's results, the results are quite similar. Gayer, Hamilton, and Viscusi find that marginal willingness to move an additional mile from the nearest Superfund site is $1085. An additional printed word about any of the Superfund sites decreases a house's price by $0.19. At an average of 550 words in length, the price decrease is $104.50 per article (Gayer and Viscusi: 2000: 439-451).

The Viscusi study shows that newspaper publicity has a similar magnitude of impact and significance for before and after a Superfund announcement. In other words, the Superfund announcement does not alter the effect of the articles on property values. Our PCB study, on the other hand, shows a difference in the magnitude and significance of impact for before and after the Superfund announcement. While the PCB before and after publicity parameters are not significantly different, the magnitude doubles, and the difference in t-values implies a difference in the effect of information dissemination, via articles, before and after the Superfund announcement.. In other words, our model shows that the Superfund announcement played a key role in the effect of additional information dissemination on property values, after the Superfund announcement. As noted earlier, the Superfund announcement clarified the severity of the PCB associated risks and focused Pittsfield residents' attention toward the information, which was then capitalized into the real estate market.

[22] B. Baker "Hazardous Waste Disposal Facilities & Residential Property Values p.51-2

Alternative Model Specifications

A logarithmic model

Other hedonic models have used a variety of model specifications to test the robustness of marginal price changes and the best model fit. There has been a mix of linear, logarithmic, and Box-Cox transformations. The Box-Cox transformation estimates the extent of non-linearity in the model from the data rather than imposing a certain model specification on the data.

Cropper, Deck, and McConnell (1988) conducted Monte Carlo experiments to determine the accuracy of the marginal prices that are estimated with various functional forms for the hedonic price equation. "When the hedonic equation was specified correctly, the quadratic and linear Box-Cox forms yielded the closest estimates. However, when the hedonic equation was misspecified because of unobserved or proxied variables, the simpler forms and linear Box-Cox performed better." (Gayer and Viscusi, 2000: 439-451). Since it is difficult to get the correct specification they believe the linear Box-Cox is the best compromise. Furthermore, "Cropper, Deck and McConnell (1988) found that a linear Box-Cox model performs well in a housing market when all attributes are observed and also in the presence of specification error," (Gayer and Viscusi, 2000: 439-451).

We use a logarithmic model with our main model, to further test the robustness of the models, as shown in Table 9 where we have a logarithmic (log-log) specification of Models 4 and 5. In order to better understand the interpretation of the logarithmic coefficients, we have included the hedonic prices next to each models' coefficients.

Hedonic prices are defined as the marginal price of a product component. For example, the hedonic price of a bathroom, as shown by the linear coefficient, is $5661 in Model 4.

We include the hedonic prices here for the logarithmic model variables to ease the interpretation of the variable impacts. Log-log model variable coefficients are typically interpreted as the percent increase in the value of a home resulting from a one percent increase in the variable. To calculate the hedonic prices we use the following formulas. Please note that βhat means the log-log coefficient for that variable. For a normal variable the hedonic price = (mean predicted sales price * βhat / sample mean of the variable). For the dummy variables noted with an asterisk the hedonic price = (mean value of sales price * (e^βhat-1)/e^(βhat*sample mean)).

Table 9: Logarithmic Specification of Models 4 and 5 T-stats are in parentheses

Log. Value of Home Explanatory Variable	Coef.	Hedonic Prices	Coef.	Hedonic Prices
	Hedonic Prices* use the dummy variable calculation			
Log. Inverse of Distance*After Superfund	-0.0799	-2638.4		
	(-3.903)			
Log. Inverse of Distance*Before Superfund	-0.044	-1452.9		
	(-1.254)			
Log. Articles*Before Superfund*1/Distance to GE			-0.0397	-808.72
			(-2.147)	
Log. Articles*After Superfund*1/Distance to GE			-0.052	-1059.29
			(-5.222)	
Superfund Dummy	-0.015	-1088.78*	0.013	937.12*
	(-0.554)		(0.407)	
Log. Distance to Center	-0.018	-435.35	-0.024	-580.47
	(-1.049)		(-1.433)	
Log. Sq.Ft.Land	0.124	0.4986	0.122	0.49
	(10.683)		(10.647)	
Sq.Ft. Live	0.355	16.02	0.353	15.92
	(123.02)		(12.998)	
Log. Baths	0.174	7672.61	0.174	7672.61
	(7.01)		(7.03)	
Fireplaces	0.163	7634.46*	0.165	11859.45*
	(8.142)		(8.32)	
Log. Age	-2.62	-3407.72	-2.66	-3459.75
	(-6.27)		(-6.39)	
Log. Age Sq.	-1.174	-21	1.194	21.35
	(5.878)		(6.006)	
Ranch	0.007	506.92*	0.007	506.92*
	(0.384)		(0.387)	
Colonial	0.051	3708.07*	0.0517	3759.25*
	(2.928)		(2.979)	
Mobile	-1.58	-57874*	-1.59	-58026.29*
	(-16.74)		(-16.967)	
Contemporary	0.155	12058.01*	0.148	11475.1*
	(3.806)		(3.632)	
Garage	0.112	7875.6*	0.11	7738.74*
	(6.732)		(6.7)	
Natural Gas	0.104	7590.4*	0.106	7737.79*
	(3.732)		(3.823)	
Oil	0.066	4771.9*	0.069	4988.8*
	(2.357)		(2.48)	
Propane	0.097	7357.7*	0.092	6961.1*
	(1.425)		(1.365)	
Log. MCAS	3.57	1089.79	3.64	1111.15
	(11.624)		(11.992)	
Log. Ethnic	1.35	1000.09	1.35	1000.1
	(6.94)		(6.968)	
Constant	-17.5628		-17.8174	
R-Squared	0.7526		0.7658	
Adj. R-Sq.	0.7492		0.7624	

Please note that these log-log models have similar R-squared's, or model fit, as our linear models, which reinforces the robustness of our models. The magnitudes and signs of the coefficients are all similar with the respective linear model coefficients. The logarithmic specification of Model 5 is interesting in the case of the two publicity variables. Both the logarithmically estimated impacts and the associated t-stats increase substantially above the linear estimated impacts and t-stats. This logarithmic model fits the data slightly better with an R-squared of 0.7658 versus the R-squared on the linear model of 0.7558, but the coefficients seem inflated. For example, with a negative impact of $1059.3 per article after the Superfund announcement, this hedonic price would suggest the total devaluation of a house, at 1km distance from the GE complex, to be $10,593, based on the average of ten articles per month. This impact seems very large. We need to keep in mind that this impact was calculated using a sample mean home's characteristics but with a distance of only 1 km from the GE complex. Due to the small issues of the calculation of hedonic prices, we rely on the more realistic linear model for our estimates.

Effects of Imputed PCB Levels and Distance from the Housatonic River

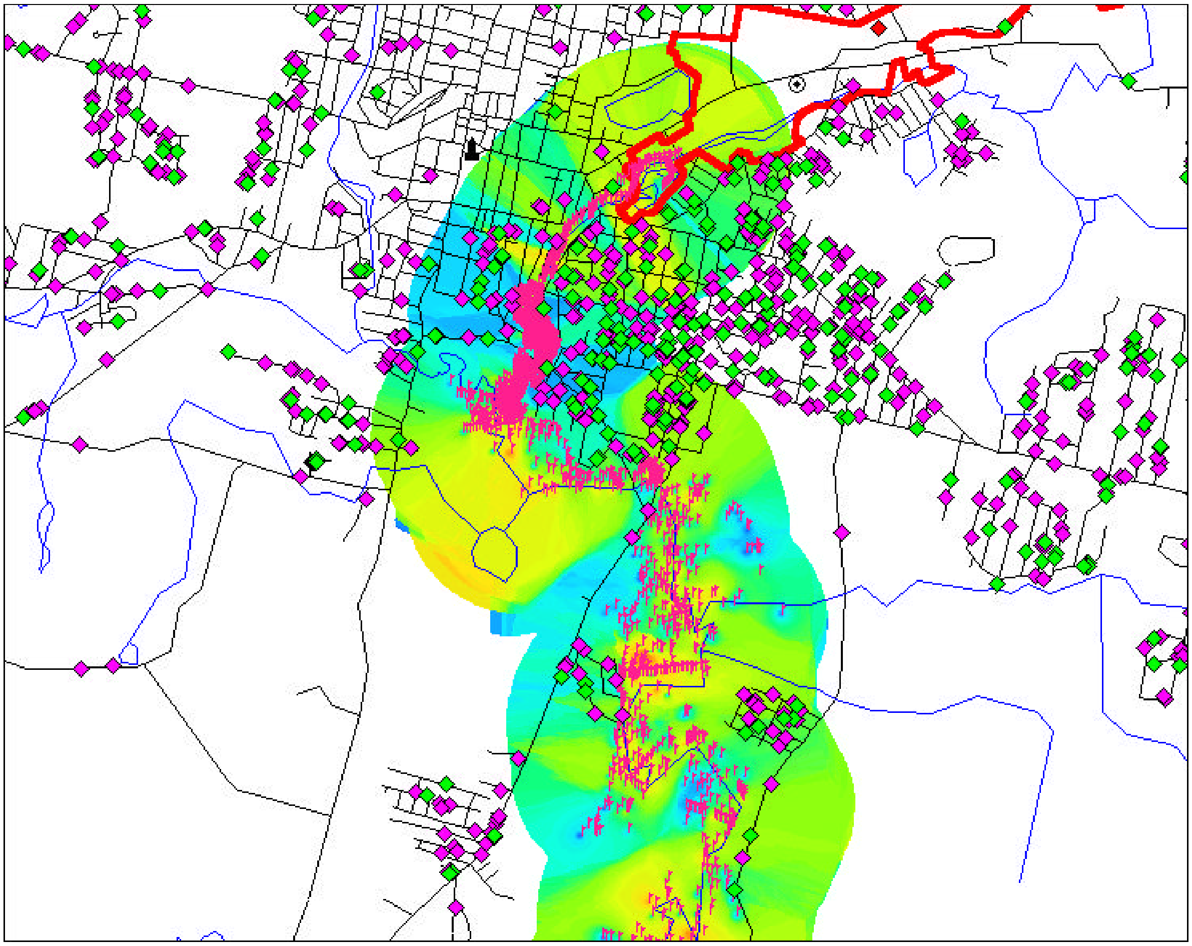
Recognizing the spread of PCB contamination down the Housatonic River and into the floodplain, we have also examined the effects of PCB levels along the Housatonic River and the proximity to the river on property values.

EPA/Weston[23] provided us with the longitude and latitude coordinates of the PCB/sediment samples taken in Pittsfield and along the Housatonic River. These coordinates were paired with the concentrations of PCBs found in the surface sediment as a function of dry weight in parts per million. Using MapInfo, a 0.7 km buffer was then constructed along the river and the area inside was divided into 5m x 5m plots. Each plot received an averaged concentration level based on all test measurements within a 0.7 km radius and each of these test measurements were then inversely weighted by the square of their distance from the 5m x 5m plot. This created a continuous PCB concentration map along the river that was used to see if specific PCB concentrations along the river have an effect on house value. These imputed PCB values were augmented in a variety of ways with distance to the river.[24]

Figures 14-16 show the imputed values of PCB contamination levels. The pink markings are flags that mark where GE and the EPA took the PCB measurements. As one can see, there is a high concentration of these flags southwest of the GE complex. This area is the first two miles of the Housatonic River where there are the highest PCB concentrations and the greatest risk to health. For further information, the EPA webpage provides extensive coverage of these testing locations and the PCB levels, for sections of the Housatonic River extending dozens of miles down the river. Figure 15 shows the buffers, spaced 100 meters apart, that help measure the proximity of a house to the river. Figure 16 most clearly shows the yellow, orange, and red spots that represent the areas of

[23] Weston is the company that has helped organize the PCB data and create the map images of the GE complex, and many other graphics seen on the EPA website.
[24] We only included homes within 700 meters from the river for this analysis. Homes further away from the river would typically not be affected by proximity to the river.

high PCB concentrations. The average PCB reading for houses in our sample is 7.2ppm and the required level for property cleanup is 2ppm.



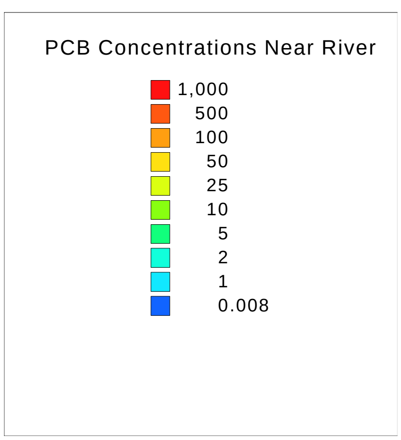


Figure 14

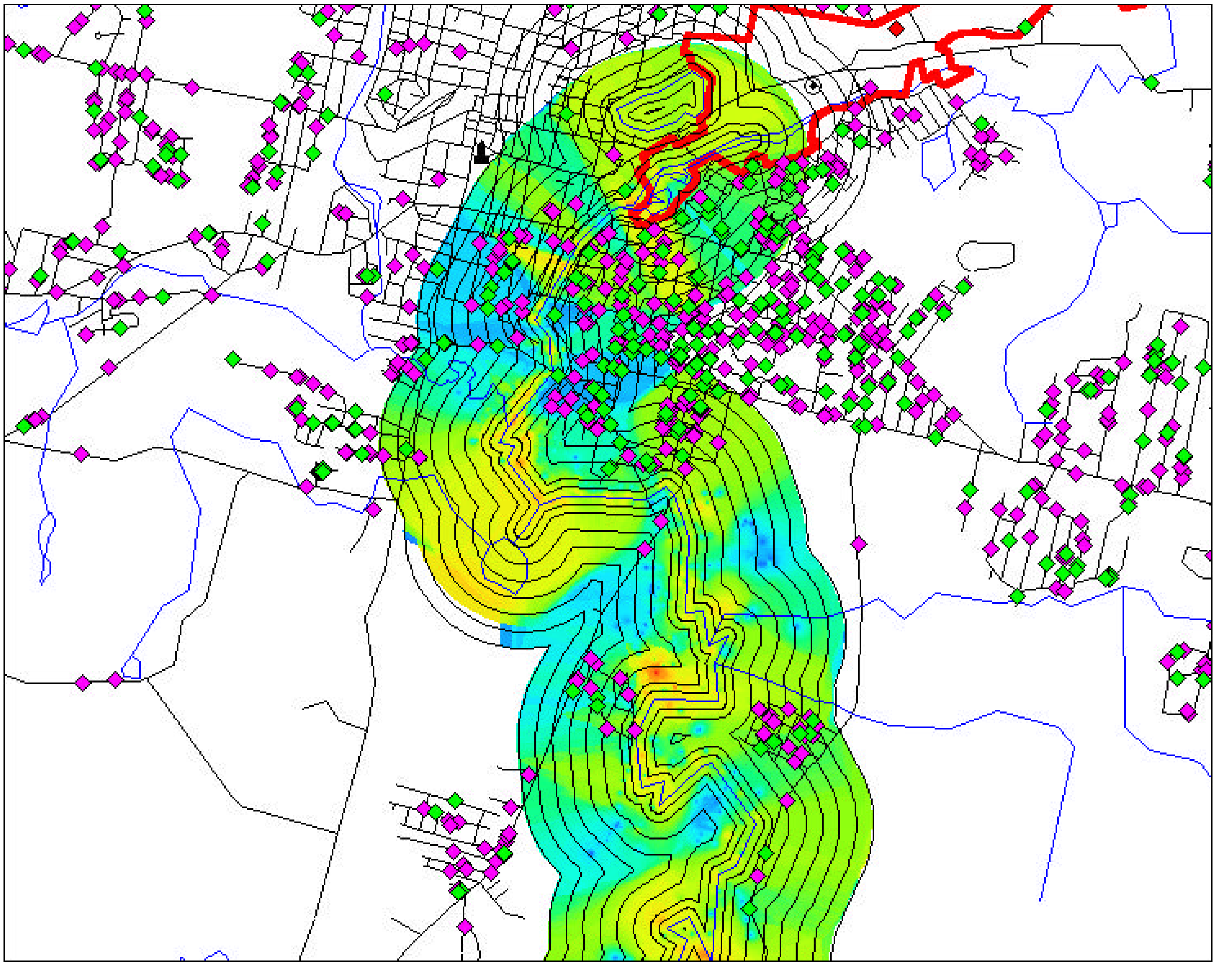
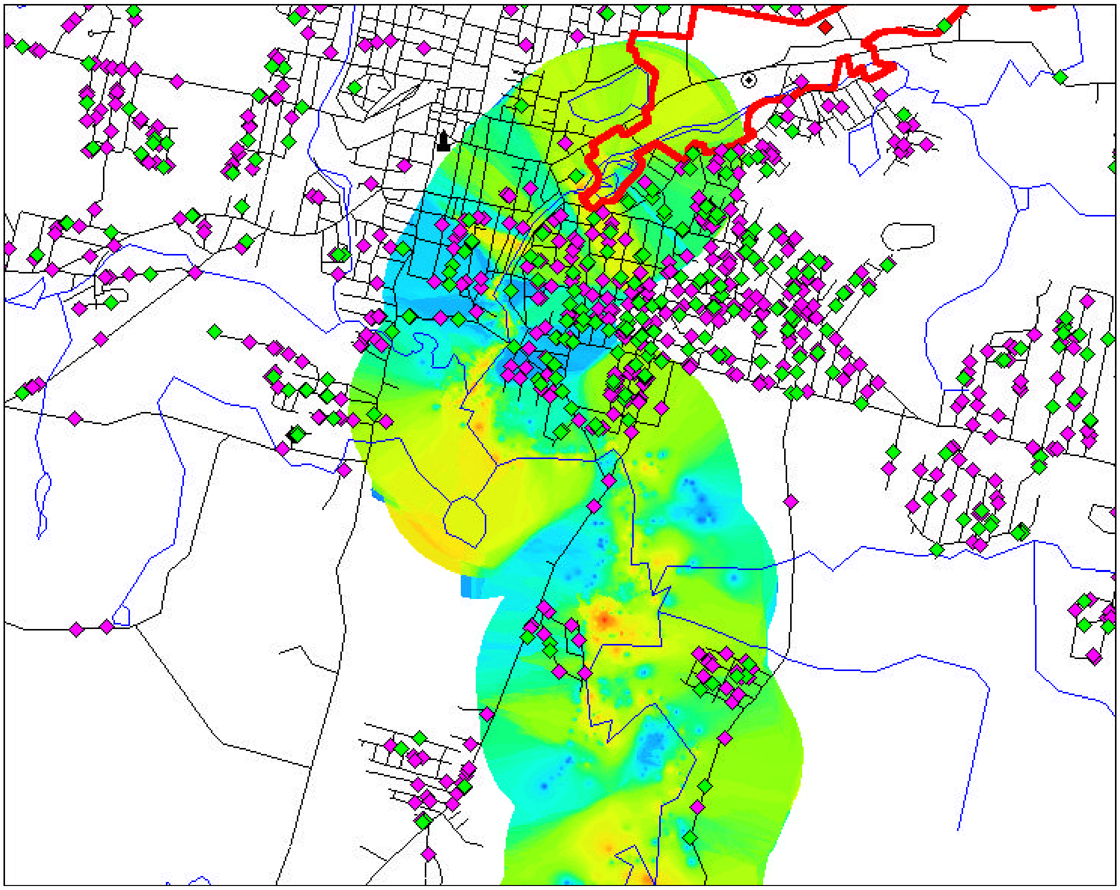


Figure 15

PCB Concentrations Near River

1,000	
500	
100	
50	
25	
10	
5	
2	
1	
0.008	



PCB Concentrations Near River

	1,000
	500
	100
	50
	25
	10
	5
	2
	1
	0.008

Figure 16

Table 10 shows Models 8-10 in which we have included various river specific variables to measure their impact on house value. The variable "PCB Level" in Model 8, reveals the impact of an additional unit of PCB contamination (1ppm) on the value of a typical home, controlled for proximity to the GE complex. While this variable is not significant, the t-value of almost –1.7 (the absolute value of two or greater means that a variable is significantly different from zero) suggests that there is a noisy recognition of PCB levels. In other words, the Pittsfield residents are to some extent aware of the high concentrations of PCBs in the river, and that these PCB levels and associated risks might factor into their bid, independent of proximity to the GE complex.

Model 9 reveals a similar impact when the PCB level variable is interacted with the Superfund dummy. As would be expected, the PCB level impact on home values is larger after the Superfund announcement, due to a heightened awareness of the contamination. While this new variable "PCB Level After Announcement" is not significant, the logic from the previous paragraph's analysis still applies.

Model 10 includes the variable "Distance to River". A priori, one might have expected that residents would be sensitive to proximity to the Housatonic River because of the contamination of the first two miles. While the high levels of contamination in the first two miles of the Housatonic River were publicized in the newspaper, the variable's t-value, below one, suggests that proximity to the river has no effect on home value. It can be argued that the recreational and scenic benefit of proximity to the river canceled out the risk-related disamenity of proximity.

Table 10: Models 10-12 With PCB Levels and Distance to River

Value of Home Explanatory Variables	Model 8 Coefficients	Model 9 T-stats in	Model 10 parentheses
PCB Level	-233.05		
	(-1.696)		
PCB Level Before Superfund		-107.94	
		(-0.427)	
PCB level After Superfund		-280.24	
		(-1.76)	
Distance from river			5510.86
			(0.811)
Distance to Center	51.28	76.13	-1926.16
	(0.043)	(0.063)	(-1.076)
Superfund	-3679.66	-2285.94	-568.3
	(-1.134)	(-0.569)	(-0.165)
1/Distance GE Before Superfund	-1832.45	-1707.5	-97.33
	(-0.946)	(-0.875)	(-0.066)
1/Distance GE After Superfund	-2510	-2528.97	-2930.96
	(-2.18)	(-2.196)	(-2.99)
Sq.Ft.Land	0.295	0.295	0.499
	(6.51)	(6.52)	(6.95)
Sq.Ft. Live	20.83	20.89	18.5
	(7.87)	(7.88)	(6.87)
Baths	8845.4	8923.3	10605.7
	(4.41)	(4.433)	(5.047)
Fireplaces	2425.8	2301.5	5497.5
	(1.298)	(1.22)	(3.1)
Age	-318.06	-322.15	62.6
	(-2.464)	(-2.49)	(0.267)
Age Sq.	0.701	0.717	-1.29
	(0.95)	(0.972)	(-1.016)
Ranch	2180	2165.8	3604.9
	(0.69)	(0.683)	(0.915)
Colonial	5115.3	5250	7302.4
	(2.01)	(2.06)	(2.83)
Contemporary	-23513	-23866.9	Dropped
	(-2.02)	(-2.042)	
Garage	3591.4	3631.06	4674.7
	(1.22)	(1.23)	(1.608)
Natural Gas	4285.24	4345.9	9876.4
	(0.983)	(0.995)	(2.15)
Oil	1010.3	1088	5702.9
	(0.222)	(0.24)	(1.23)
Propane	-10553	-11227.6	-9067.8
	(-0.647)	(-0.685)	(-0.52)
MCAS	1423.8	1427	1599
	(6.674)	(6.68)	(5.62)
Ethnic	-31.9	-27.3	-235.3
	(-0.101)	(-0.086)	(5.62)
Constant	-306944	-309385	-335957
R-Squared	0.7832	0.7835	0.7909
Adjusted R-Sq.	0.765	0.7643	0.7759
Observations	259	259	284

Further exploration of this model might include only the homes near the highly contaminated first two miles of the Housatonic River.

The fact that there were no significant results attributed to either distance from the river or to the imputed PCB levels does illuminate a limit to the amount of information that the Pittsfield residents can absorb and act on. From this model we could infer that the Pittsfield residents capitalize *well-publicized* information about the GE complex and the adjacent portions of the Housatonic River into their value estimates of a home. Yet, on more ambiguous issues, such as the PCB levels and risks associated with the lower sections of the Housatonic River, we can infer that the residents react to a general ambience of environmental problems rather than search for any information about specific hazards at certain areas.

PCB contaminated properties

We did not incorporate fill contaminated properties into a model due to a lack of data. While locations of the PCB contaminated properties were provided by the EPA, few of these houses were sold in the 1996-2000 period, and no cleanup dates are available. As an added note, the average fill contaminated property was 1.69km from the point in GE and .92km from GE in buffers. Six were sold before the Superfund announcement and 11 after. Average value is $55,945.50. Average age 1951, which coincides with the fill program.

Brownfield Redevelopment

As mentioned earlier in Part I, the 254-acre GE complex is classified as a brownfield because of its underused and abandoned portions as well as the PCB contamination. Industrial property laws are written such that the current occupier of contaminated property, or a former brownfield, is responsible for future problems that result from contamination that might have been caused by a past owner. Recently, efforts have been made to rewrite these laws and provide legal protection for those companies who relocate to brownfield sites. On April16, 2001, the U.S. Senate passed a Brownfields Restoration Act that "provides liability protection for innocent parties, such as contiguous owners, prospective purchasers, and innocent landowners. The bill provides for funding and enhancement of state cleanup programs, etc," (www.brownfields.com/story_senateact.cfm). The Congress will most likely add sections to the act regarding public safety as related to brownfield contamination.

Despite these efforts, companies do not readily relocate to the GE site on account of Pittsfield's current unattractiveness for industry. First, the low levels of higher education stand out as a workforce issue. While 78% of residents, 18 years old or above, have a high school diploma or the equivalent, only 26% of residents, 18 years or older, have an Associate degree, Bachelor's degree or higher. The community is also very remote and there are significant transportation issues due to a lack of freeways. A important issue is that Route 7 runs through the downtown of several cities making it difficult to move semi-trailers in a timely fashion.

In response to these issues, General Electric will carry out a redevelopment plan for an unused portion of the site, in an effort to lure new companies and new commercial life to Pittsfield. The plan consists of demolishing the buildings and cleaning the underlying soil of PCBs to a set level, safe for industrial purposes. The EPA estimates the costs of this project at $50 million. After the cleanup, GE will transfer this portion of the site to the Pittsfield Economic Development Authority (PEDA).

An Analysis of the Costs of Cleanup and the Resulting Benefits as Measured by Property Value Differentials

In order to begin our analysis of the costs of cleanup and the resulting benefits, we must delineate the various areas of contamination and specify which areas where most likely capitalized into the real estate market, and for which areas we were able to discern impacts.

The following three sections are a breakdown of the areas that should be considered in the costs of cleanup and as a result the parties that will benefit from such a cleanup.

GE Facility and other Contamination Sources such as the Old Municipal Landfill

The GE complex, as outlined on Figure 6, is the main source of contamination and the focus of our models. Our models measure the external costs that are capitalized into property values as a function of proximity to the GE complex. Thus we can use these costs estimated by the hedonic model to calculate the aggregate benefits to Pittsfield property values that would result from a cleanup of the GE complex and the adjacent first half-mile of the river. We can then compare these benefits to the costs incurred by GE and the EPA in the cleanup process. These calculations and the resulting implications will be discussed in a moment. First we should consider the other PCB related costs that were not measurable in our model.

Properties and Contaminated Public Areas such as Parks

As mentioned above, we were unable to include the value damage of direct property contamination and the resulting value benefits of cleanup. Considering the small number of these homes in the sample, 17, these should not have had a large effect on the coefficients. Furthermore, we have no cost information for residential property cleanups. Assuming we had all of this data, we could have compared the costs of property cleanups with the property value differential that resulted from the cleanup.

There are several public areas such as parks that contain PCB contaminated fill as a result of the GE fill program of the 1940s and 50s. GE has identified many of these parks and has cleaned up these areas to safe recreational PCB levels. The risks associated with these contaminated neighborhood parks were certainly capitalized into property values, yet due to time constraints and the large number of parks, we were unable to explore this portion of the real estate market.

The Housatonic River

There are three portions of the Housatonic River that need to be discussed separately: the first half-mile stretch; the next mile-and-a-half stretch; and the rest of the river. The first half-mile of the Housatonic River was directly included in the model as a portion of the GE complex, and therefore the associated capitalized risks as measured in out model would be included with those for the GE complex as a whole. The next mile-and-a-half stretch of the river was not directly examined in our models. It is possible that this river portion had an effect on proximity to the GE complex for homes southwest of the complex, therefore we might also explore this effect in our cost and benefit calculations. Finally, the rest of the river had no apparent statistically significant effect on the value of homes in our sample as shown by our imputed PCB level and river proximity models. It should be considered however, that for separate real estate markets further south along the Housatonic River, that there might possibly exist property devaluations as a function of the associated health risks, and the loss of river recreation. In summary, any estimates of the benefits of cleaning up the contamination in the Housatonic River are conservative due to unmeasurable effects that extend downriver into Connecticut.

Costs of cleanup

The Consent Decree, signed in early 1999, outlines the agreement between GE, the City of Pittsfield, and the EPA. General Electric is fully responsible for the testing and removal of PCBs on the factory site, two miles of the Housatonic River, and its filled oxbows and adjacent floodplains. GE projects that the costs of this cleanup will be $150 million while the EPA estimates $250 million.[xxvi]

In order to facilitate the comparison of the costs of cleanup and the aggregate damages (the benefits that result from cleanup) one must note that our model does not directly include the second mile and a half stretch of the river, which is included in GE's estimated costs of cleanup.

Aggregate Damages

The aggregate damage to all Pittsfield houses within 8km of the GE complex was calculated using U.S. Census information and MapInfo. The census information breaks the city down into census tracts and further down into city blocks. We calculated the average distance of the blocks within each census tract and used these distances together with the number of houses per tract to calculate the damage per tract.

Table 11: Aggregate Damages

	Total 1	Total 2	Total 3	Total 4
Info Source	Model 3 to 2.93km	Model 4	Model 5	
January 2001 Dollars	93,652,298.34	62,963,410.69	71,161,831.79	86,115,641.83

Table 11 shows four aggregate damage totals as calculated using data from three different models. In all cases but Total 4 we subtracted the before Superfund impacts. We do this so that we focus on the after Superfund impacts on value, and not on the before Superfund impacts that might theoretically include the non-PCB externalities. Thus, by subtracting out the pre-Superfund impacts, we hope to calculate only the PCB-related impacts on property values.

We will explain these calculations so that the reader can follow our logic.

Total 1: (Model 3) Number of houses (Distance* 791-(Distance*2618.6-5359.5))

If we look back at Figure 13 we see that the above equation calculates the height between the "before" and "after" Superfund curves. Likewise, moving from 0 to 2.93km we see that the height between the curves, which represents the impact, diminishes with distance, which is intuitively what we expect to see. Using this equation, we can calculate the impact for a given distance and multiply this by the number of houses at this distance. The negative impact diminishes to zero at 2.93km and accordingly we end our impact estimation here. For homes further than 2.93km from the GE complex, there is a premium placed on the value. This premium is not included in the damage estimation because it is a side effect of the changes in market demand rather than a benefit of the PCB damages.

Total 2: (Model 4) Number of houses (1950/distance-526/distance)

Note that this equation calculates the total damages, which includes the negative effect on property values. We subtracted the before Superfund impact from the after Superfund impact.

Total 3: (Model 5) Number of houses ((1546/distance) +357 – (338.2/distance))

This equation is similar to that above and then we adjusted the coefficients to reflect the number of articles for before and after the Superfund announcement: 10 for after and 3.8 for before.

Total 4: (Model 5) Number of houses ((1546/distance) +357 + (338.2/distance))

This Total calculation is the same as for Total 3 except for the fact that the before Superfund impact is added rather than subtracted from the after Superfund impact. We do this to reveal the full damage of all articles, or information dissemination, for both before and after the announcement.

The average of the four damage totals is $78,473,295.66, which is a little over half of General Electric's cleanup cost estimate. As noted earlier, we must keep in mind the slight differences between what is capitalized into property values and measured for in these models, and what GE is paying to cleanup. In my opinion, the most important difference is that our model does not include the impact of the second portion of the Housatonic River (the one-and-a-half mile stretch) while GE's cost estimate includes this area.

Conclusions

This case study has shown the general feasibility of calculating the external costs of a polluting industry that are absorbed in the real estate market, and that are measurable as property value differentials. In conducting this analysis, we have examined the role of information dissemination and we have calculated the aggregate damages for a final analysis of the net benefits of a PCB cleanup in Pittsfield. In conclusion, we will compare the costs of cleanup to the damage estimates (benefits of cleanup), summarize our findings about the role of information dissemination in the real estate market, and finally apply this knowledge in a case of company and pollution management.

General Electric has estimated that a cleanup of the GE complex, the two mile stretch of the Housatonic River, and its former oxbows and adjacent floodplains will cost $150 million. Our models, on the other hand, have estimated an aggregate damage of roughly $80 million. It is quite apparent that the costs of cleanup exceed our estimation of the benefits that could result from a reversal of the impacts on property values. In this case, we are unable to claim that the reversal of property value damages alone makes it worthwhile, or economically justifiable, to pay the cleanup costs.

A closer estimation of the property value damages that result from the second mile-and-a-half stretch of the Housatonic River could bring the damage estimates closer to the costs, thus providing a clearer economic justification for the expenditure. Additionally, there are many intangible costs such as health and environmental damages that are difficult to calculate, but that would certainly add a large dollar amount to the damage totals. Therefore, in order to justify these cleanup expenditures society must conjecture about the value of other things that have been damaged by the contamination, such as the environment, that will benefit from the cleanup of the PCB contamination. After reading Part II of this thesis, the reader can make this judgment for himself/herself.

There are two alternative interpretations of this analysis. Assuming that these intangible costs were *zero*, it would be more efficient to allow GE to *not* clean up all of the contamination, but in exchange to provide compensation to Pittsfield and the property owners in excess of the $80 million. Similarly, if General Electric were bankrupt and the cleanup costs were *less* than the property value gains from cleanup, than the Pittsfield residents could pay out of pocket for the cleanup and they would still be compensated be the gains in property value over what they spent on cleanup.

We have seen that each Berkshire Eagle article provided the Pittsfield residents with new and updated information about the risks associated with PCBs and proximity to the GE complex. While the residents were to some extent aware of these risks since the early 1980s, these risks were not capitalized into the real estate market at a high enough level to produce a statistically significant impact on property values. The Superfund announcement of August 4, 1997 was an important event that focused and updated individuals' previous perceptions about the severity of the PCB related risks. At the same time, there was an influx of Berkshire Eagle articles that disseminated information about specific health risks and new areas contaminated with PCBs. As a result, a larger amount of these risks were capitalized into the real estate market, and there was a statistically significant impact on house values.

In summary, the information dissemination portion of this study shows that information is not transmitted instantaneously but rather that there is a flow of information that continually updates risk perceptions. Furthermore, a highly publicized event like the Superfund announcement can act as a "magnifying glass" that focuses attention on the key issues and heightens sensitivity to further information about risks.

Finally, this study can be seen as a case in management for other firms, especially industrial companies. Our aggregate damage totals only provide a minimum amount of the liability for which a polluting firm can be responsible. These damage totals *are* a minimum estimate because, as mentioned earlier, they do not include damage to individual properties, health problems from exposure, environmental damage, etc. Being aware of this minimum of liabilities and the large value to which these liabilities could potentially reach, should help companies adjust their behavior through the inclusion of external costs in their decisions. Hopefully this will result in a lower level of pollution and greater precautions against accidental leaks into the environment.

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[i] http://www.epa.gov/superfund/programs/npl_hrs/nplon.htm
[ii] http://www.ci.pittsfield.ma.us/comm_history.html
[iii] http://www.ci.pittsfield.ma.us/comm_history.html
[iv] www.housatonic-river.com/hri_community.html
[v] Article:"GE, EPA, DEP, Mayor and others negotiate while public waits" www.housatonic-river.com/rapids_spring99.html
[vi] www.epa.gov/region01/ge/pcbshealth/pcbfact.pdf
[vii] From a conversation with Prof. David Dethier from the Williams College Geology Department Nov.2000
[viii] www.housatonic-river.com/hri_community.html
[ix] A special PCB settlement section from the Berkshire Eagle Oct. 26 1998
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[xii] www.epa.gov/region01/ge/pcbshealth/pcbfact.pdf (1997) pp. 2-3

[xiii] Theo Stein, "GE plans to staunch PCB leaks into river," Berkshire Eagle 8 October 1998.
[xiv] www.housatonic-river.com/hri_community.html
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[xvi] "Community-based Environmental Science: The Pittsfield PCB Story," 3 Tapes
[xvii] "Community-based Environmental Science: The Pittsfield PCB Story,' 3 Tapes
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[xix] From an email from Angela Bonarrigo EPA, October 2000
[xx] www.epa.gov/superfund/sites/npl/nar1492.html
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[xxii] www.housatonic-river.com/hri_community.html
[xxiii] www.epa.gov/region01/ge/pcbshealth/pcbfact.pdf
[xxiv] www.housatonic-river.com/hri_community.html
[xxv] Holly A. Taylor, "Risky Business: A Tale of two cancer studies," Berkshire Eagle 26 April 1995.
[xxv] Theo Stein, Berkshire Eagle, 26 October 1998.

Appendix: Variable Descriptions

The price and structural data come from the Multiple Listing Service of the Berkshire County Board of Realtors. A Geographic Information System (GIS) called MapInfo program, was used to determine the longitude and latitude coordinates of the house and computes distances from each house to a spot on the GE site. Buffers were also create around the entire GE complex so that we could compare the effects of distance from the plant in general as an overall risk and eyesore as compared to the true risk of a certain hotspot within the plant area.

EPA/Weston provided us with the longitude and latitude coordinates of the PCB/sediment samples taken in Pittsfield and along the Housatonic River. These coordinates were paired with the concentrations of PCBs found in the surface sediment as a function of dry weight in parts per million. A 0.7 km buffer was then constructed along the river and the area inside was divided into 5m x 5m plots. Each plot received an averaged concentration level based on all test measurements within a 0.7 km radius and each of these test measurements were then inversely weighted by the square of their distance from the 5m x 5m plot. This created a continuous PCB concentration map along the river that was used to see if specific PCB concentrations along the river have an effect of house value. This effect will be compared with a simple buffer along the river as a general risk of the PCBs in the river.

We also used the GIS technology to link each house with the demographic data of its census tract. The census data we focused on were: race, education, and vacancy. The education and vacancy variables were insignificant so we removed them from the model. We have included % white residents in the model as it contributes to the neighborhood characteristics and because of its significance.

We searched the Berkshire Eagle archives for all articles with the word PCBs. The headlines for each article were read for level of connection with GE or with the PCBs in Pittsfield. In other words, election platforms and results that might mention PCBs as an afterthought are not included in the count. The number of articles per month were counted and the average of three months of articles prior to a sale will be included for each house sale in the data.

House Characteristics- Received from the Berkshire Multiple Listing Service for houses sold in the town of Pittsfield from January 1, 1996 to October 31, 2000.

Style

Many regions in the U.S. tend to differ in how real estate agents categorize the style of a home. In this data set, the styles are not totally consistent with our opinion about what attributes qualify a home style as belonging to a certain style. Additionally, among sample homes sold more than once, there are differences in which style has been coded. While there are many inconsistencies, this information is used to create a better model fit and a clearer hedonic model. These style coefficients should not be used for real estate purposes with any great amount of confidence.

The Style variables have been combined into five different groups based on the how a house of this style would look, in addition the styles' coefficient's behavior in a preliminary model. New Colonial includes Colonial, Saltbox, and New England Farmhouse. New Ranch includes Ranch, Embanked Ranch, Raised Ranch, and Split-

Level. Contemporary and Mobile Houses have their own individual categories due to their large coefficients. The last category is excluded from the regression, Default Homes. This category included Log, Garrison, Victorian, Cape, Cottage, Bungalow, Other, Tudor, etc. Many of these styles have too few observations. (MLS data)

Square Feet of Living Area

The area of living space within each home. This variable varied widely from the small mobile homes to the large contemporary homes. (MLS data)

Square Feet of Property Acreage estimates and lot dimensions were translated in square feet for a uniform variable. (MLS data)

Bathrooms Number of bathrooms in the home. The numbers include half-baths and quarter baths at the real estate agent's discretion. (MLS data)

Fireplaces Total number of fireplaces in the house. (MLS data)

Garage A dummy variable with "1" for garage and "0" for no garage. (MLS data)

Fuel A decent number of the observation listed more that one fuel type. I focused on four primary fuel types, Oil, Natural Gas, Propane, and Electric as the fuel dummy variables. Solar, Wood, and Coal were also listed for a home in addition to the above primary fuel types, but I discarded them as secondary fuel sources. Occasionally, two of the four primary fuel sources were listed and in this case I chose the first fuel listed. Electric is the omitted dummy variable in the regression. (MLS data)

Age and Age Squared

The MLS data provided the year the home was built and from there we calculated the age using the year 2000. Additionally, we calculated age squared in order to capture the effect of "older home charm." (MLS data)

Closing Date

Taking into consideration the lengthy process of buying a home, we have adjusted the closing dates by ten days. If a closing was coded during the first ten days of a month, we designated that as a sale from the previous month. This date adjustment is important for the CPI adjusted of the sale price. (MLS data)

Superfund Dummy variable

DiVillars announced his nomination of the GE/Pittsfield complex and the Housatonic River as a Superfund site on August 4, 1997. To create the dummy variable and to adjust for a lag in real estate market adjustment, we pushed the Superfund cutoff back to August 15, 1997. All sales before or on this date have "0" as the dummy variable and all sales after are "1".

MapInfo Variables

The geocoding/mapping software package enabled us to locate each home on a Pittsfield map and to determine its geographic coordinates. A few homes had incorrect addresses or were located outside the Pittsfield town lines. While these observations were included in the summary of the mean house, the absence of some variables caused these observations to be removed from the regression.

Distance to GE Complex

Based on an EPA map of ground water contamination due to GE/PCB spills, we chose a "hotspot" on the GE complex as a point for measuring distances to each observation home. We used MapInfo to determine the geographic coordinates of this spot and then calculated the distance using to coordinates of the other home. MapInfo was also used to create buffers of 200 meters around the GE complex. Buffers are the measure of proximity that are used in the data discussion.

Distance to the Center of Downtown Pittsfield

We calculated the distance from each home to the center of the traffic circle in Downtown Pittsfield in a similar manner as the distance to GE. This variable helps control for access to the downtown area. The GE complex is not far from the downtown, so this is a very important variable for separating out the effects.

Interaction Variables: Superfund Dummy and Distance to GE Complex

This variable is used in two different ways. (Superfund*Distance GE) calculates the effects of proximity to GE for homes sold after the Superfund announcement. The other interaction variable (Distance GE*(1-Superfund)) calculates the effects of proximity to GE for homes sold before the Superfund announcement.

Selling Price

The selling price was indexed using a monthly CPI with base year 1982-4. The regressions are all computed with the indexed real price to account for changes in inflation. (MLS data)

MCAS

Massachusetts Department of Education November 21, 2000

I took an average of Math, Science and Technology, and English Language Arts scores for 4th grade. The elementary schools seem to be those with the greatest influence on house choice, as they have the greatest variance in “quality”.

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