Alan K. Reichert, PhD

Impact of a Toxic Waste Superfund Site on Property Values

This study analyzes the impact on property values of a toxic waste Superfund in Uniontown, Ohio. During the period of peak publicity surrounding the controversy, property values within 6,750 feet of the landfill declined significantly. The diminution in property values was directly related to proximity to the landfill, with impacts ranging from approximately 5% for the most distant properties to 15% for the closer properties. Estimated damages associated with approximately 1,600 residential and certain commercial properties totaled just under $11 million.

Uniontown, located in the northeast portion of Ohio just north of Canton and a little southeast of Akron, has a population of approximately 10,000. The 30-acre landfill known as the industrial excess landfill (IEL) is about one mile south of the center of Uniontown, close to many residential and commercial properties. The IEL began as a sand and gravel mining operation in the 1950s. From 1966 to 1980, when it was ordered closed, the facility operated as both a municipal and industrial landfill. The landfill accepted a variety of household trash and commercial liquids (latex and organic solvents), sludge, and various solid wastes. The liquid wastes were dumped directly into a large lagoon or mixed with solid wastes.

After a series of fires, the County Board of Health banned the dumping of industrial wastes, but the landfill continued to accept residential trash until 1980. It was soon apparent that toxic waste had begun to contaminate the groundwater, which became a major concern to homeowners who were on well water at the time. In addition, significant accumulations of explosive methane gas were discovered in basements near the landfill. During 1984, the IEL was placed on the EPA's Superfund list and in 1989 a class-action suit was filed on behalf of approximately 1,600 property owners.[1]

LITERATURE REVIEW

The following literature review represents only a small portion of the studies related to contaminated properties found in the literature. The results of these studies, along with

1. In a class-action suit filed on behalf of property owners in Uniontown, the jury awarded the defendants $6.7 million in aggregate damages in December 1994.

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the Uniontown results, will be used to illustrate the range of impacts one can expect to find from severely contaminated properties. Further, the combined results of the studies will help identify how property impacts vary by distance.

Kohlhase[2] wrote about the impact of an announcement declaring that a landfill is being placed on the EPA's Superfund list. Eight landfills in the Houston, Texas, area that were placed on the Superfund list by 1985 were analyzed. The study examines the impact on surrounding housing prices in 1976, 1980, and 1985. A linear multiple regression model is estimated that includes a standard set of housing and neighborhood characteristics, plus a measure of distance to the nearest landfill. The model generated an R^2 of 83%. Distance to the landfill was measured in both absolute and quadratic form to allow for decreasing marginal distance effects. A sample of 1,511 homes within seven miles of at least one of the landfills was used in the study. Her research found that Superfund listing creates a market for "safe housing" since nearness to the toxic site was perceived as a disamenity in 1985. The model indicates that housing prices increase at a decreasing rate of up to 6.2 miles from the landfills. For the typical home located at an average distance from each of the landfills, reducing the distance to the landfill by one mile depresses property values by $2,364.

Further, the impact of the landfill is not proportional. Her model estimates that the average value of a home would increase by $4,940 if it were moved from a lot adjacent to the landfill to a location one mile away. If the house were then moved two miles from the landfill, its value would rise by an additional $4,259; an additional $3,476 would be added at three miles; an additional $2,606 would be added at four miles, etc. The maximum increase in value is approximately $17,700 at a distance of seven miles. In addition, while loss estimates varied by site, they seemed to be unrelated to the degree of pollution. To test the robustness of these results, additional analysis was conducted using repeat sales, alternative data sets, and other functional forms. The results were essentially the same.

In 1992, Smolen et al.[3] examined the impact of the Envirosafe landfill located in Oregon, Ohio, on the east side of the Toledo metropolitan area. Envirosafe accepts a low-level category of hazardous waste from a variety of sources across the United States. While the appropriate state and federal environmental regulators indicate that the landfill meets the required safety regulations and is not a health threat, a continuing debate is reported among local residents regarding the long-term safety of the facility. The authors collected data on several housing characteristics for 1,227 property transactions between 1986 and mid-1990. The average selling price for the sample during 1989 was $57,138. Proximity to the landfill was measured in miles for properties located within one of three centroid distance ranges: 0–2.6, 2.61–5.75, or more than 5.75 miles from the landfill. A control sample of 49 properties sold during the 1989–1990 period in a comparable neighborhood located a substantial distance from the landfill was also included. The most consistent results were obtained for properties within 2.6 miles of the landfill. With their eight-variable aggregate model, which generated an R^2 value of 57%, the results indicate that sales prices increased by $8,141 for each additional mile the property is located away from the landfill.

Miller[4] studied the impact of a nuclear waste leak at the Feed Materials Production

TABLE 1 Impact in Average Dollars and Percentages for Properties One Mile Away from a Landfill

Kohlhase (Houston, Texas)	$12,728	16.2%
Smolen, Moore, Conway (Toledo, Ohio)	8,141	14.2%
Reichert (Uniontown,Ohio)	7,880	7.6%
Miller (Fernald,Ohio)	7,188	12.0%
Overall average impact	$8,984	12.5%
Standard deviation	$492	3.4%

2. Janet Kohlhase, "The Impact of Toxic Waste Sites on Housing Values," *Journal of Urban Economics* (July 1991): 1–30.
3. G. Smolen, G. Moore, and L. Conway, "Economic Effects of Hazardous Waste Landfills on Surrounding Real Estate Values in Toledo, Ohio," *Journal of Real Estate Research* (1991): 283–295.
4. N. Miller, "A Geographic Information System-Based Approach to the Effects of Nuclear Processing Plants on Surrounding Property Values: The Case of the Fernald Settlement Study," Working Paper, University of Cincinnati, March 31, 1992.

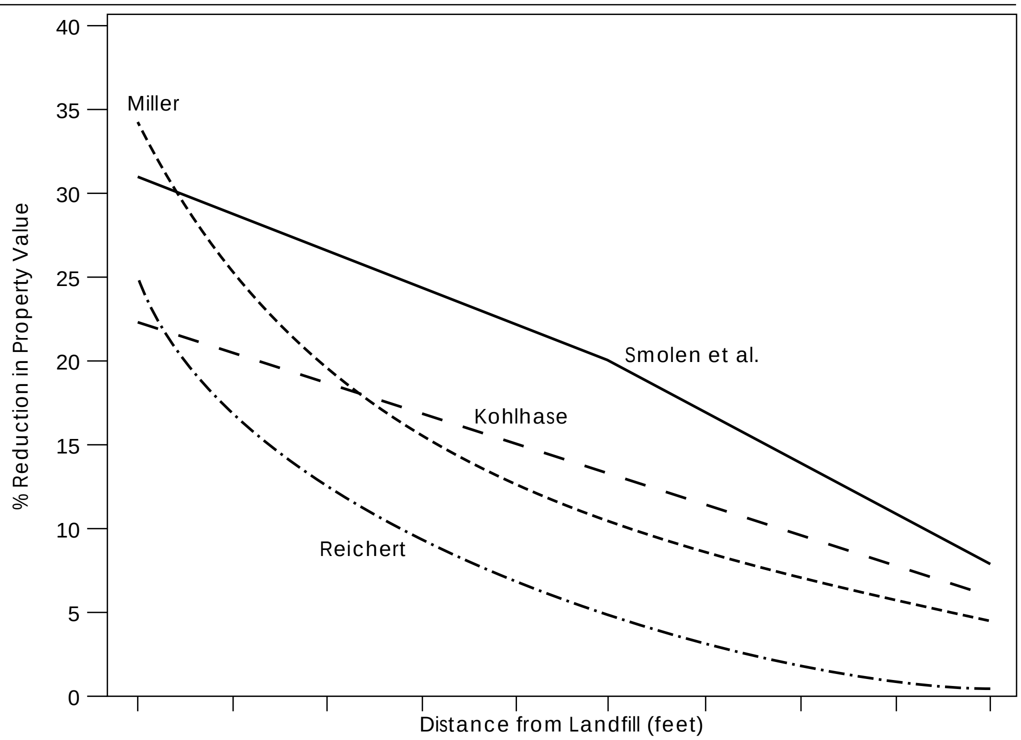
Facility (FMPC) near Fernald, Ohio, and operated by the U.S. Department of Energy. The case involved leaks of both airborne and groundwater nuclear contaminates. The facility contains over 1,000 acres of rural land in southern Ohio. The subject area was defined as those properties within five miles of the FMPC site. A control area was included in the analysis. Analytical techniques included comparison of price trends, assessed valuations, and turnover rates within the subject and control areas; repeat sales analysis within the subject area; and selected case studies. The study found that property devaluation was limited to within two miles. For residential properties directly bordering the FMPC, a 35% reduction in value was reported. For properties within one mile, the reduction in property values ranged from 12%–20%. Between one and two miles, the reduction in property values was reported to be in the 5%–12% range.

As previously mentioned, the current study finds that property values within 6,750 feet of the landfill experienced a statistically significant decline in value. The diminution in property values was directly related to proximity to the landfill, with impacts ranging from approximately 5% for the most distant properties to 15% for the closer properties.

With adjustments made to the four individual study findings for differences in surrounding housing values, distance from the landfill, and timing, the range of impact in dollars and percentages is shown in Table 1. Figure 1 plots the percentage diminution in property values against distance to the landfill or source of contamination for each of the aforementioned studies plus the current study results. To help generalize the results, an exponential curve was fitted to the results reported in this paper (labeled "Reichert" in Table 1) and a log regression curve was applied to the Miller results. A linear trend was used to summarize the Kohlhase results, and a kinked linear trend was employed with the Smolen et al. findings.

The range of impacts for the sample of four studies was 7.6%–16.2%, with an average impact of 12.5%. In terms of dollar impacts, the range was $7,188–$12,728, with an

FIGURE 1 Property Impact by Distance



	0	1,125	2,250	3,375	4,500	5,652	6,750	7,875	9,000	10,125
Reichert		14.66%		6.4%		5.5%		0.9%		
Miller	35%		18%					8.5%		5%
Kohlhase	22.5%					16.2%				10.8%
Smolen et al.	31%					20%				7.3%

average value of $8,984. The standard deviations are $492 and 3.4%, respectively.

In a comprehensive review of the literature, Schultze et al.[5] also found that the reduction in market value for properties located within one mile of a hazardous waste site was approximately $10,000. At the same time, for properties located beyond one mile, the empirical evidence is much less clear. In their words, "The distance (or market size) over which property values may be affected by a disamenity such as a hazardous waste facility is one of the largely unresolved issues in property value studies." The current study provides additional evidence concerning the relevant market size and provides important evidence on the slope of the distance gradient for property values, as suggested by Schultze et al.

When a major toxic leak is announced, the market may become less liquid and property values may be permanently reduced.

VALUATION THEORY

Property Devaluation

A home represents both a consumption and an investment good that provides a flow of housing services (e.g., safety, shelter, and personal satisfaction) capitalized at an appropriate discount rate when its value is being determined. A negative externality can impact housing values in several ways. Unpleasant odors, excessive noise, and health and safety concerns can reduce the value of the flow of housing services, for example. From an investment perspective, the difficulty of obtaining financing and the costs associated with meeting health regulations (such as water purification) can increase the rate at which these services are capitalized. Both effects work to reduce the market value of the affected property. In an efficient market, potential home buyers and real estate investors use all available information to estimate the likely decline in the values of these housing services and any potential increase in investment risk. The purchase price will then be discounted accordingly.

When negative news, such as a major toxic leak is announced, the market reaction may take several different forms. First, there may be a temporary liquidity effect as sellers are reluctant to adjust their price expectations downward immediately and as potential buyers attempt to assess the probable long-term impact on market value. Consequently, the market will become less liquid as evidenced by a significant reduction in the volume of sales transactions and a noticeable increase in average "days on the market." Second, a permanent reduction in property values may take place once the market reestablishes a new equilibrium that fully reflects the reduced flow of housing services and/or increased investment risk.

Liquidity Effects

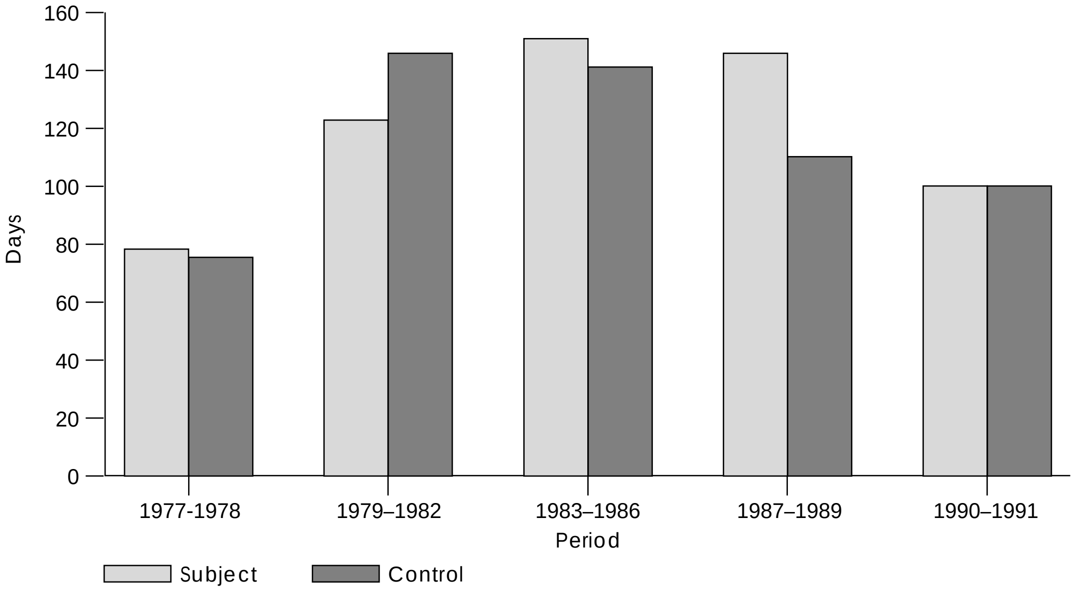
A negative externality may increase the length of time required to sell a given property, imposing significant opportunity costs on property owners. Data was collected on time-on-the-market for properties sold between 1977 and 1991 in both the subject area and a comparable control area. (Because of the difficulty in obtaining reliable days-on-the-market information, the market time analysis was conducted only through 1991. Further, a slightly different control group was used for the market time analysis than that which is used in the price analysis.)

This period was divided into five distinct economic periods. The 1977–1978 period was one of strong housing demand and represents a period that preceded the publicity surrounding the IEL problem. As indicated in Figure 2, the average marketing times for residential properties in both the subject and control areas were almost identical (80 days). The next three years (1979–1982) witnessed a dramatic decline in housing demand caused by a severe recession and very high mortgage rates. Not surprisingly, marketing time increased dramatically in both regions, but the average time on the market was approximately 25 days less in the subject area compared with the control.

Figure 2 indicates that, as the publicity surrounding the IEL developed, the relationship between the two average marketing times reversed, with the average number of days in the control area now less than what was reported in the subject area. This was especially evident during the 1987–1989 period when the average marketing time for the subject area reached approximately 145 days in the subject area compared with only 110 days in the control area. In relation to the 1979-1982 period, this represents a net change of approximately 60 days in favor of the control area (i.e., a shift from a difference of -25 days to a difference of +35 days). During the final period (1990–1991)

5. W. Schultze, G. McClelland, M. Doane, E. Balistreri, R. Boyce, B. Hurd, and R. Simenauer, *An Evaluation of Public Preferences for Superfund Site Cleanup: A Preliminary Assessment* (Washington, D.C.: U.S. Environmental Protection Agency/Office of Policy, Planning and Evaluation, March 1995): 1–77.

FIGURE 2 Marketing Time Analysis



the two marketing times are once again equal, suggesting that a new and likely lower market equilibrium has been established.

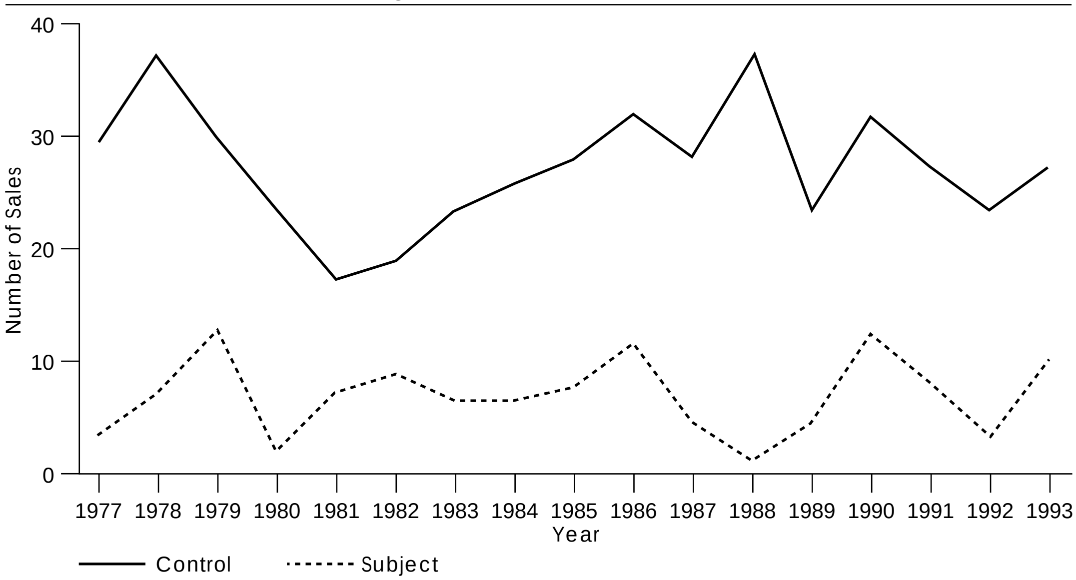
In terms of sales activity, Figure 3 indicates that the annual sales volume for properties located closest to the landfill (ring 1) and those located in the control area were closely correlated throughout most of the period, with the exception of 1988, which represents the end of the peak publicity period, surrounding the IEL.

Price Effects

Housing prices may differ due to differences in size, style, age, or the presence of various housing amenities. Further, proximity to positive externalities, such as a public park, or negative externalities, such as a landfill, can have a major impact on local property values. In regression analysis, control variables are explicitly included to account for each of these positive or negative housing characteristics. This allows the model to identify the individual influence of any given housing characteristic by holding constant the influence of the remaining factors.

Two alternative functional forms are frequently used in hedonic housing models: the linear and log-linear models. The linear model implies constant partial effects between

FIGURE 3 Annual Sales Volume: Ring 1 Versus Control Area



housing characteristics and selling price, while the log-linear model allows for nonlinear price effects. This study utilizes a Cobb-Douglas[6] exponential log-linear functional form, in which the regression coefficients on the continuous variables represent price elasticities, and the coefficients on the categorical variables indicate the percentage impact on price of that housing characteristic. For example, if a house has a fireplace, the regression coefficient on the categorical fireplace variable (e.g., 0.05) represents the market value of a fireplace measured in percentage terms (5.0% of the total market value). As mentioned, the liquidity effect analysis suggests that a new market equilibrium was established by 1990, meaning that a one-time permanent downward price adjustment took place during the 1988–1989 period. This log-linear model is used to test this hypothesis:

$$lnP = b_o + b_1(lnX_1) + b_2(lnX_2) + \ldots + b_n(lnX_n) + a_oD_o + \ldots + a_mD_m + e \qquad (1)$$

where,

P = Nominal selling price

$X_1..X_n$ = A series of continuous housing characteristics, such as square footage of living space, age, lot size, etc.

$D_o..D_m$ = Various categorical (dummy) variables such as style, air conditioning, etc.

b, a = Estimated regression coefficients on the continuous and categorical variables, respectively

e = A random error term

Data

Information on homes sold in the Uniontown area were obtained from the multiple listing service (MLS) for January 1977–May 1994. The variables used in the model are listed in Table 2. These variables are common to most statistical real estate appraisal models and are structured in a conventional manner.

Control Area

A control area serves as the benchmark against which the price behavior of houses in the subject area are compared. A control group is used to account for various factors that affect housing prices in general. Examples include changes in interest rates, employment, and property taxes. The effects of these general factors are eliminated when the subject area and the control area are compared. To serve as an effective control area, the region should be sufficiently far from the landfill to

TABLE 2 Variables for Log-Linear Model

1. LPRICE = Selling price (nominal terms)
2. LAGE = Age of property at time of sale (years)
3. LSQFT = Square feet of living space
4. FRPL = Presence of a fireplace (1 or 0)
5. CAIR = Presence of central air conditioning (1 or 0)
6. BSMT = Presence of a partial or full basement (1 or 0)
7. POOL = Presence of an in-ground swimming pool (1 or 0)
8. BATHS = Total number of full and half baths
9. BEDRMS = Number of bedrooms
10. NEW = New house (1 or 0)
11. LLOTSIZE = Lot size in square feet
12. GARAGE = Size of garage (square feet)
13. BUNGALOW, BISPLIT, COLONIAL, RANCH (the base) = Style of house (1 or 0)
14. D2250, D4500, D6750, D9000 = Location of the property as measured by one of four concentric circles radiating from the landfill (1 or 0)
15. MAJORRD, MINORRD = Location of property on a high- or medium-traffic road (1 or 0)
16. HSCHOOL = High school district (1 or 0)
17. CTYWATER = Presence of city versus well water (1 or 0)
18. YRxx = Year of sale (1 or 0 for each of 17 years)
19. QTRxx = Season (first, second, third, or fourth quarter)
20. Dddyr = Interaction between year of sale and distance from the landfill (1 or 0)

6. H. Kang and Alan Reichert, "An Evaluation of Alternative Estimation Techniques and Functional Forms in Developing Statistical Appraisal Models," *The Journal of Real Estate Research* (Fall 1987): 1–29.

be unaffected by the toxic emissions and should contain housing of the age and types found throughout the subject area. The property in the control area closest to the landfill is 8,000 feet away. Table 3 provides basic descriptive statistics on several key factors, such as age, size, and style for properties in both the subject and the control areas.

Distance Effects

Distance variables were included in the model. It seems likely that properties closer to the landfill would suffer the largest economic loss, and those farther away might experience a smaller, but still meaningful, impact. To test this relationship, the distance from the nearest edge of the landfill to the middle of each property was measured in 50-foot increments, and each property in the subject area was placed into one of four equal-width concentric distance rings. Thus, ring 1 includes properties within 2,250 feet of the landfill; ring 2 includes properties between 2,251 feet–4,500 feet; ring 3 includes properties between 4,501 feet–6,750 feet; and ring 4 includes the remaining properties out to 9,000 feet.

Annual Effects

A variety of important developments occurred in the real estate market during the last half of the sample period. For example, in 1989, the EPA released its remediation plan; soil tests continued to provide conflicting evidence regarding the nature and extent of the underground contamination; houses immediately surrounding the IEL were removed; and arrangements were made to bring city water into the area. It can be argued that this information potentially had both positive and negative implications for homeowners. The EPA's proposed remediation plan was viewed as a positive step by certain residents and as grossly inadequate by others. Further, the availability of city water could alleviate the well water contamination problem but at a cost of approximately $6,000 per homeowner to cover assessments and hook-up fees. To capture any potentially beneficial impacts related to the availability of city water, a variable was included in the model to indicate whether the sale took place after the homeowner was hooked up to city water.

While the liquidity analysis suggests that the impact of the landfill was quickly felt,

TABLE 3 Summary Statistics: Subject Area Versus Control Area (1977–1987)

Subject Area

Characteristic	Mean	Minimum	Maximum	Standard Deviation
Price	68,243	23,000	155,000	16,350
Building size (square feet)	1,688	660	3,200	342
Lot size (square feet)	23,484	6,956	174,350	13,262
Year built	1973	1907	1987	—

Style	(%)	Bedrooms	(%)	Baths	(%)
Ranch	25.9	1	0.1	1.0	10.8
Colonial	33.2	2	2.9	1.5	20.4
Bi-/split-level	38.6	3	53.7	2.0	24.0
Other	2.3	4	41.3	2.5	42.0
		5	1.8	3.0+	2.8

Control Area

Characteristic	Mean	Minimum	Maximum	Standard Deviation
Price	65,793	34,000	118,000	12,547
Building size (square feet)	1,660	1,040	2,600	280
Lot size (square feet)	20,397	10,440	54,400	6,859
Year built	1977	1962	1987	

Style	(%)	Bedrooms	(%)	Baths	(%)
Ranch	21.3	1	0.0	1.0	0.0
Colonial	27.0	2	0.7	1.5	22.3
Bi-/split-level	48.6	3	70.3	2.0	29.1
Other	0.8	4	27.7	2.5	33.4
		5	1.3	3.0+	3.0

given the variety of potentially positive and negative information reaching the market, a set of annual impact variables was developed. These variables are extremely flexible and would allow for a continuing decline, a potential recovery, or as previously hypothesized, a stabilization in property values. The use of these annual impact variables makes no *a priori* assumptions about a continuation of trends within or between different time periods. In effect, each year is treated as an independent observation. A series of dummy variables is included in the model to indicate the interaction of distance to the landfill as measured by each of the four concentric distance rings and the date of sale.

These interaction variables were formed by taking the product of these annual and distance categorical variables. For example, the categorical variable, D2278, represents the product of the categorical variable year (YR78—not shown in Table 4) times the distance variable, D2250 (i.e., within 2,250 feet of the landfill). These interaction terms are calculated for each year from 1978 to 1994, with 1977 and the control area serving as the base for year of sale and distance, respectively. Thus, the regression coefficient on each of these annual dummy variables indicates how average housing prices in that distance ring for a specific year behave compared with the control area in 1977. For example, if the regression coefficient on D2278 is 0.10, properties within 2,250 feet of the landfill in 1978 sold for 10% more than properties located in the control area during the base year, 1977. All subsequent impacts are measured in relation to housing prices in the control area during 1977. Figures 4 through 6 plot these annual impact coefficients for the entire 17-year period for the first three rings. Given that a relatively small number of sales occurred in each distance ring, it is not surprising that random yearly fluctuations appear throughout the entire period.

Before and After Effects

Initial statistical tests that examined changes in appreciation rates for several submarkets surrounding the IEL confirmed that, by 1988, appreciation rates within the subject area began to decline significantly in relation to appreciation rates in the control area. This period coincides closely with the dramatic increase in negative publicity surrounding the landfill. Thus, the period from 1977 through 1987, called the pre-IEL period, was considered to be free from any statistically significant landfill effects. The period from 1988 through the end of the sample period (May 1994) was considered the post-IEL period.

To reduce the impact of random factors on the annual impact coefficients, the values of the individual annual impact coefficients were averaged over both the pre- and post-IEL subperiods. The bold straight lines depicted in Figures 4–6 graphically represent these two average values. The estimated impact of the IEL for each distance ring is then calculated as the difference between these two average values. A pooled *F*-test was con-

FIGURE 4 Percentage Impact on Housing Prices: Within 0–2,250 Feet of IEL (Ring 1)

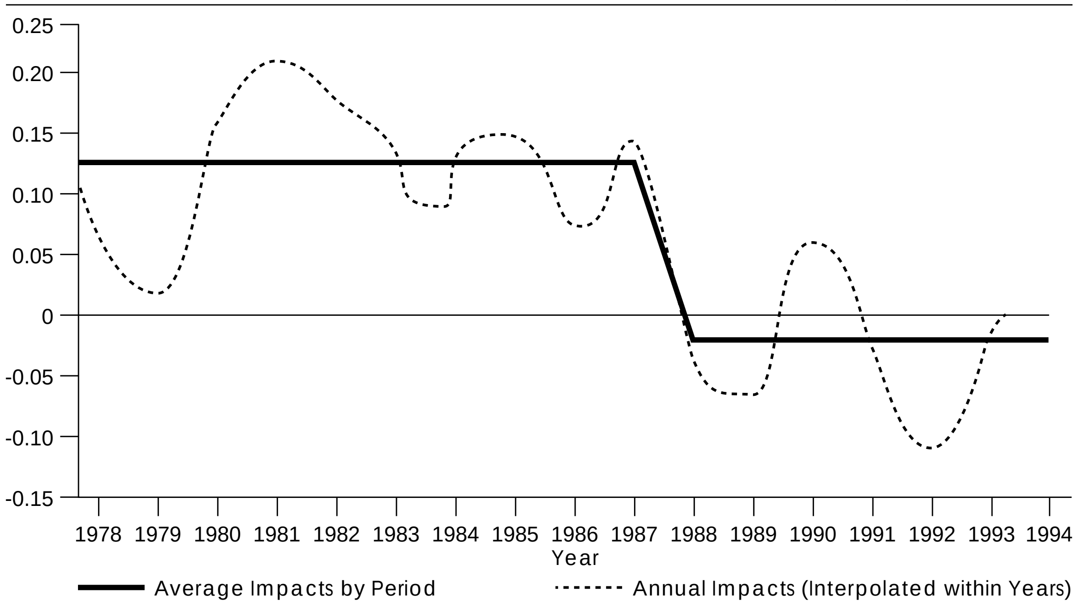


FIGURE 5 Percentage Impact on Housing Prices: Within 2,251–4,500 Feet of IEL (Ring 2)

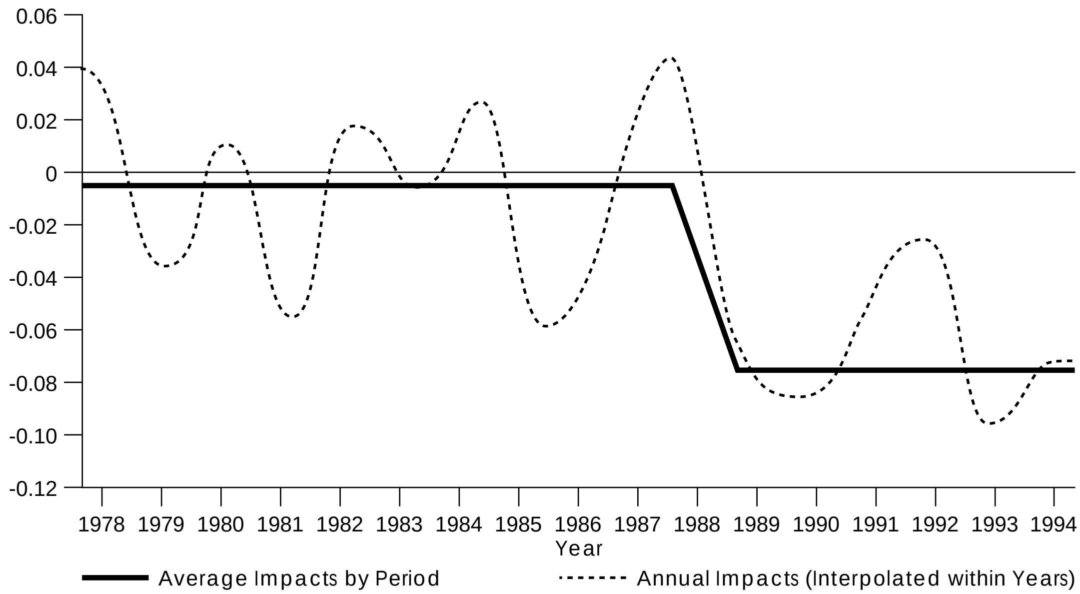
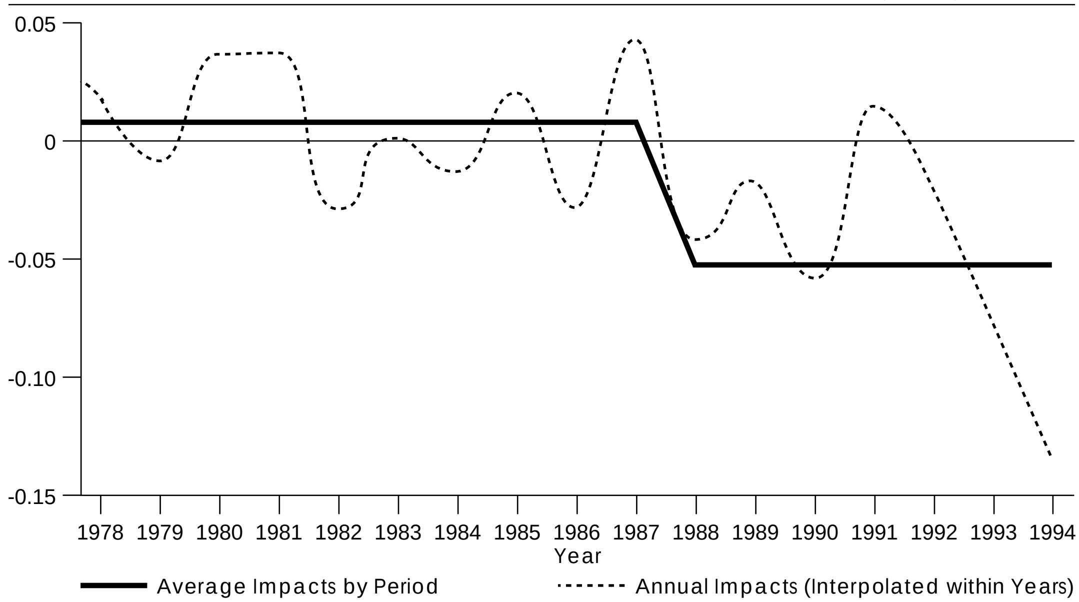


FIGURE 6 Percentage Impact on Housing Prices: Within 4,501–6,750 Feet of IEL (Ring 3)



ducted on the difference between the means of the two sets of regression coefficients to identify any statistically significant shifts.

REGRESSION RESULTS

A set of partial regression results illustrating the impact on properties located in ring 1 is presented in Table 4. The model generated an adjusted R^2 of approximately 84%, and an overall F-value of 67.2. (Tests for autocorrelation, heteroscedasticity, and multicollinearity generally indicate that the model is adequately specified and that the data are not severely ill conditioned.) All the physical characteristic variables in the model were statistically significant and had the expected signs with the exception of minor road (MINORRD) and city water (CTYWATER). For example, the three most significant variables in the model are log of square feet of living space (LSQFT), log of the age of the house at time of sale, and log of the number of baths (BATHS). The regression coefficient on LSQFT is 0.347, which indicates that, on average, a 10% increase in square feet will generate a 3.47% increase in selling price. The coefficient on age (-0.092) indicates that a 10% increase in age would generate a 0.9% reduction in market value.

TABLE 4 Partial Set of Regression Results Illustrating Impacts on Ring 1*

Dependent Variable: LPrice	*N:* 1,394	Multiple *R:* 0.922
R^2: 0.849	R^2: 0.837	Standard Error of Estimate: 0.105

Variable	Coefficient	Standard Error	*T*	*P* (2 Tail)
CONSTANT	7.335	0.167	43.982	0.000
BEDRMS	0.022	0.006	3.489	0.001
BATHS	0.080	0.007	10.831	0.000
LSQFT	0.347	0.022	15.951	0.000
LAGE	-0.092	0.006	-14.490	0.000
NEW	-0.102	0.014	-7.153	0.000
LLOTSIZE	0.071	0.009	7.715	0.000
FRPL	0.045	0.008	5.366	0.000
CAIR	0.052	0.007	7.876	0.000
GARAGE	0.039	0.009	4.194	0.000
BSMT	0.030	0.011	2.838	0.005
BUNGALOW	-0.073	0.017	-4.285	0.000
BISPLIT	-0.071	0.009	-8.026	0.000
COLONIAL	-0.039	0.010	-3.776	0.000
MAJORRD	-0.063	0.020	-3.169	0.002
MINORRD	0.003	0.012	0.217	0.828
HSCHOOL	-0.045	0.015	-2.936	0.003
POOL	0.056	0.020	2.793	0.005
CTYWATER	-0.007	0.033	-0.198	0.843
QTR2	0.025	0.008	3.016	0.003
QTR3	0.040	0.009	4.500	0.000
QTR4	0.050	0.009	5.433	0.000
D2250	-0.051	0.056	-0.908	0.364
D4500	0.048	0.026	1.841	0.066
D6750	0.010	0.028	0.345	0.730
D9000	0.049	0.012	4.194	0.000
D2278	0.106	0.071	1.487	0.137
D2279	0.300	0.066	0.458	0.647
D2280	0.164	0.096	1.715	0.087
D2281	0.205	0.073	2.801	0.005
D2282	0.175	0.071	2.445	0.015
D2283	0.109	0.074	1.481	0.139
D2284	0.151	0.074	2.046	0.041
D2285	0.118	0.072	1.645	0.100
D2286	0.073	0.066	1.109	0.268
D2287	0.147	0.079	1.862	0.063
D2288	-0.023	0.122	-0.192	0.848
D2289	-0.052	0.080	-0.660	0.509
D2290	0.063	0.066	0.965	0.335
D2291	-0.007	0.071	-0.104	0.917
D2292	-0.106	0.080	-1.321	0.187
D2293	0.012	0.068	0.174	0.862

* The annual dummy variables are not shown. Upon request, the author will provide a full set of regression results. Call (216) 687-6958 or e-mail sumbreeze@aol.com.

As already mentioned, the regression coefficient on the categorical variables is a direct measure of the percentage impact on market value. Thus, the results indicate that the presence of central air conditioning adds 5.2% to the value of a home, while an in-ground pool typically adds 5.6% to market value. On the other hand, homes located on a busy street sold at an average discount of 6.3% compared with identical houses located elsewhere. In terms of style, the results indicate that the least expensive homes for a given square footage are bungalows and bi-/split-levels. The coefficients on the three quarterly variables reflect seasonality in housing prices. The results indicate that houses selling during the third and fourth quarters command a price averaging 4%–5% above the first quarter base.

The regression coefficients on the yearly dummy variables measure the annual rate of price appreciation across the entire sample in relation to the base year, 1977. The coefficients indicate the rapid appreciation during the late 1970s and the slowdown during 1981–1983. The coefficients on the four distance ring variables (D2250, D4500, D6750, and D9000) show how the average prices of properties in the four distance rings compare with the prices in the control area throughout the entire sample period. The remaining set of interaction variables shows the impact of both location and time on housing values in the subject area compared with housing values in the control area.

DAMAGE CALCULATIONS

The results of the regression model are used to calculate the average annual impact on properties less than 75 years old. (Damages on residential properties older than 75 years are calculated using tax assessment data.) For properties that sold after 1987, losses were calculated at time of sale by using the regression model to predict a property's market value in the presence of the landfill. The value of the property in the absence of the landfill was then calculated by dividing this estimated price by one minus the impact coefficient calculated for the appropriate distance ring and year of sale. These losses were then adjusted for changes in the Consumer Price Index between the year of sale and May 1994.

For properties that did not sell in the post-IEL period, the damages as of 1994 were calculated by comparing the predicted market value of these properties in the presence of the landfill and their predicted "but for" values as of May 1994. Property damages for individual properties in the subject area were then totaled to provide an estimate of aggregate damages for the entire class.

The impact on residential properties older than 75 years old, vacant lots, and commercial properties with a residential component (e.g., multifamily properties, apartments, and small office buildings) were determined, using the most recent market value estimates for these properties as determined by the county tax assessor's office. The appropriate distance-related percentage impacts previously discussed were then applied to these market value calculations to establish losses. No attempt was made to quantify the impact of the landfill on agricultural land and structures, nonresidential commercial properties, or a wide variety of special-use properties such as, schools, churches, recreational parks, etc.

Damages are calculated for only the first three distance rings (within 6,750 feet from the landfill) where the *F*-test results indicated a high level of statistical significance. The average percentage loss and their associated level of statistical significance for each of the distance rings are indicated in Table 5. The impact coefficients represent the average effect experienced by all properties in each ring. Properties closest to the landfill in each distance ring more than likely suffered a larger impact than did properties toward the outer edge of any given ring. (See the results of fitting an exponential curve to the ring-specific impact coefficients depicted in Figure 1.)

Damage estimates in 1994 dollars for residential properties less than 75 years old are summarized in Table 6. The average percentage loss in market value for properties located in ring 1 was -14.66%, and the average dollar loss in residential properties less than 75 years old was $15,809. The corresponding losses for ring 2 were -6.40% and $7,072, while the comparable impacts for ring 3 were -5.48% and $5,046. Losses associated with older houses and commercial proper-

TABLE 5 Impact and Statistical Tests

Ring	Impact %	*F*-test**	Probability
1	-14.66%	26.5	0.00
2	-6.40%	21.0	0.00
3	-5.48%	15.3	0.00
4	-0.97%*	0.7	0.80

* Decrease is not statistically significant.

** Test of equality of mean regression coefficients between the pre- and post-IEL periods using a pooled *F*-test.

TABLE 6 Average Loss Estimates by Ring

	Ring 1	Ring 2	Ring 3	Total
Number of Properties	225	509	484	1,218
Minimum loss	$7,745	$3,141	$2,322	$2,322
Maximum loss	$25,448	$11,301	$8,857	$25,448
Average loss	$15,809	$7,072	$5,046	$7,880
Total	$3,556,917	$3,599,489	$2,442,024	$9,598,430

TABLE 7 Aggregate Losses by Property Type

	Volume	Losses
Vacant lots	207	$152,172
Older houses	55	$270,686
Duplex/triplex	67	$656,898
Residential/commercial	39	$282,452
Total damages	368	$1,362,208

ties that have a residential component are summarized in Table 7. Thus, the aggregate damages associated with the entire set of 1,586 properties totaled $10,960,637.

CONCLUSION

The analysis illustrates that toxic waste landfills have a relatively quick, economically significant, and permanent impact on housing values. The study indicates that a temporary liquidity effect is likely, as evidenced by a reduced volume of sales and an increase in marketing time. At the same time, once housing prices fully adjust to the realities of a contaminated marketplace, the liquidity effect disappears. Thus, houses located near a landfill will begin to sell at a normal pace but at a significantly reduced price. Unfortunately, the ultimate effect is the permanent reduction of real property value within a considerable distance from the contaminated site.

REFERENCES

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