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The Impact of Landfills on Residential Property Values

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Abstract. **The purpose of this study is to determine the impact of five municipal landfills on residential property values in a major metropolitan area (Cleveland, Ohio). The study concludes that landfills will likely have an adverse impact upon housing values when the landfill is located within several blocks of an expensive housing area. The negative impact is between 5.5%–7.3% of market value depending upon the actual distance from the landfill. For less expensive, older areas the landfill effect is considerably less pronounced, ranging from 3%–4% of market value, and essentially nonexistent for predominantly rural areas.**

Introduction and Study Objectives

The purpose of this study is to determine the impact of municipal landfills on residential property values in a major metropolitan area (Cleveland, Ohio). It seems clear that homeowners have personal and financial incentives to protect their environment and the value of their real estate investment. Even industrial firms, which themselves generate a variety of waste, no longer view the environment as a convenient and inexpensive means of disposing of waste.

The scope of the waste disposal problem has grown enormously. In a recent study, Hanley [7] using EPA data, reports that 180 million tons of municipal solid waste was generated during 1988. This translates into 4.0 pounds of waste per person per day and this figure is expected to grow by 25% by the year 2010. The EPA estimates that 72.2% of the waste is disposed of in landfills compared to 14.2% that is burned, and 13.1% that is recycled. Hanley indicates that the total cost of operating a 100-acre landfill from acquisition through closure is approximately $50 million. Given these rising costs, over one-third of the nation's 6,000 landfills are expected to close by 1995. Other, less visible costs of landfills are the potential impact upon health and safety of local residents and the possible impact upon residential property values.

This study specifically examines: (1) the likely impact on market value of a decision to locate or expand a landfill near residential properties, (2) the price-distance relationship to estimate the marginal influence of proximity to a landfill, and (3) market's perception of the impact of landfills upon various quality-of-life and health factors, and (4) the effect of a landfill upon the rate of housing price appreciation and market liquidity.

A survey of homeowners living near landfills indicates that the most severe nuisances are odor and unattractiveness, while toxic water run-off and methane gas were mentioned

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as the most severe health issues. Not surprisingly, the farther from the landfill, the weaker the impact of the nuisance factors. The findings suggest that homeowners who own more expensive homes are more sensitive to landfill problems. Almost 30% of the respondents felt that the landfill had a severe adverse impact on selling price and marketability, while 17% felt the landfill could induce homeowner flight.

Data on housing sales indicates that landfills will most likely have an adverse impact upon housing values when the landfill is located within several blocks of an expensive housing area. The negative impact is between 5.5%–7.3% of market value depending upon the actual distance from the landfill. For less expensive, older areas the landfill effect is considerably less pronounced, ranging from minus 3%–4%, and essentially nonexistent for predominantly rural areas. The results of the current study should be useful to homeowners, real estate developers, mortgage lenders, fee appraisers, realtors, tax assessors, environmentalists, and public policy makers who frequently deal with zoning and other land use issues.

Literature Review

While not intending to be an extensive review of the growing environmental impact literature this section summarizes a number of recent studies that specifically address the impact of various types of landfills on homeowner attitudes and housing values. There is a significant amount of empirical literature dealing with the impact on housing values of a variety of environmental issues such as air, noise, and water pollution (Harrison and MacDonald [8]; Harrison and Rubenfeld [9]; McMillan, Reid and Gillen [18]). At the theoretical level Freeman [5] surveys the issues relating to hedonic price models used to estimate the impact of environmental factors on housing prices.

In the area of waste disposal the famous Love Canal environmental disaster and the publicity surrounding the EPA's Superfund have focused a significant amount of attention upon the impact of hazardous waste sites on property values. For example, Adler et al. [1] examined the impact of hazardous waste sites on property values in two cities: Pleasant Plains, New York and Andover, Minnesota. The study provided limited support for a negative landfill effect in Pleasant Plains. In another study by Schulze et al. [25], housing markets near three California cities were examined for potential hazardous landfill effects. In only one region did houses within 1000 feet of the site report significant results.

Kohlhase [12] analyzed the impact of toxic waste sites in the Houston area on residential housing values and found that when EPA adds a site to the Superfund list a new market for "safe" housing develops. Housing prices reflect a premium of up to $3,310 per mile as distance to the site increases. Furthermore, these premiums disappear once the site has been cleaned up.

In an important study that has particular relevance to this study, McClelland, Schulze and Hurd [17] analyze the effect of risk perceptions on property values surrounding a hazardous waste site. The authors surveyed residents located near a large landfill located in the Los Angeles area. Opened in 1948, the landfill began accepting hazardous waste in 1976, stopped handling hazardous material in 1983, and finally closed a year later. Homes were built around the landfill and initial plans called for recreational facilities to eventually be built on the site.

While various experts and health officials determined that there was no significant health risk associated with the landfill, local residents were not totally convinced. The survey of resident attitudes revealed a bimodal distribution of risk perceptions. That is, a significant proportion simply dismissed the risk while others exaggerated its extent. The survey revealed that younger respondents and women generally perceived the landfill to be a greater risk. Furthermore, the study indicates that the residents interpreted odor from the landfill as a signal of potential health hazards.

Using an hedonic regression model, the study identified the impact of risk perceptions upon housing values and found that an increase of 10% in the proportion of respondents who felt the landfill represented a high risk reduced property values by $2,084. Furthermore, closing the landfill reduced the percentage of respondents classifying the landfill as high risk by 24%, which translated into a $5,000 gain in housing prices. These findings also suggest that housing prices would have been $9,795 or 7.2% higher if the landfill had never been built. The study also found that the positive impact of closure was reflected in improved property values within a few months. It was interesting to note that distance from the landfill did not prove to be a significant predictor. While distance was a significant factor in influencing risk perceptions, it was also found to be partially redundant with square footage and year built, and hence failed to make an independent contribution to selling price.

In another recent article, Cartee reviewed several unpublished studies that looked at the impact of sanitary landfills on property values [4]. The studies employed very different methodologies, data samples, and various degrees of analytical rigor. While the findings were not entirely consistent, the general conclusion appears to suggest that sanitary landfills do not have a large impact on real estate development activity and prices. In fact, in one case, the development of a sanitary landfill required a sufficiently large investment in infrastructure improvements, such as access roads, utilities, drainage, etc., that an increase in property values actually took place.

Theory and Methodology

Theory

The presence of a landfill can impact property values from both the supply and demand side. Even though land may be relatively inexpensive near a landfill, contractors may be hesitant to build and lenders may be reluctant to extend credit on properties located on or near landfills due to potential legal liabilities. On the demand side, buyers who are aware that a landfill exists in the area and who are concerned about potential nuisance and health problems will either avoid these properties or be induced to purchase them only at a significant discount. Whether the health problems are real or imaginary may not be the critical issue since people often act on the basis of perceptions, as well as fact. Furthermore, as summarized in the McClelland et al. article, there is a growing body of evidence to suggest that when faced with low probability risks, people generally tend to either ignore or exaggerate the risks involved [17].

As pointed out by McClelland, Schulze and Hurd, risk assessment by individual sellers may have little impact upon housing prices compared to the risk perceptions of the entire neighborhood. To illustrate, assume most residents in a given neighborhood are generally unconcerned with the risk or nuisance associated with a landfill. While an individual seller may have a strong aversion to the landfill and be willing to sell at a sizeable discount, the homeowner may still be able to sell at the current market price and avoid a large loss. This is especially true if potential buyers are not fully aware of the landfill and its associated effects. For example, in the McClelland study, 62% of recent home buyers indicated that they were unaware of the landfill at time of purchase.

On the other hand, as the neighborhood becomes more concerned with the landfill, homes prices are likely to decline. To some extent the market experiences a self-fulfilling prophesy. If local residents exaggerate the negative aspects of a landfill and are anxious to leave the area at virtually any cost (i.e., neighborhood flight), the supply of housing offered for sale will be large. If buyers are fully informed about the landfill and its associated risks, they will either avoid the area altogether, reducing demand, or perhaps attempt to benefit from the problem by making substantially below-market offers. Any such decline in prices will be quickly reflected in the appraisal process by local realtors and professional appraisers. Sellers will be encouraged to price their homes even lower to remain competitive and a downward price spiral may develop.

Thus, the nature of the housing stock and attitudes of the local residents can make a significant difference. If the housing stock is generally inexpensive, of lower quality, and owned by residents who are older and perhaps less well educated, local homeowners may simply ignore any nuisance problems and potential future health hazards. If buyers with similar attitudes and risk profiles are attracted to the area, there may be little or no noticeable landfill impact. On the other hand, in areas where the population is younger and better educated, very concerned about health issues and child safety, and has a significant housing investment to protect, the potential adverse landfill impact could be significant.

In a well-known article Muth postulates that housing prices follow a definite spatial pattern, exhibiting a consistent decline as the distance from the central business district (CBD) increases [21]. The decline in value reflects increased commuting time and transportation costs required to reach the CBD and the greater availability of land at the urban fringe. The existence of these negative price gradients have been confirmed empirically by various researchers, such as Lie and Brown [14] and Jackson [10]. While the CBD represents a positive externality a similar argument can be made that a positive price gradient should be observed for housing located near a negative externality, such as a landfill. Instead of transportation costs affecting price, the negative effects of a landfill (e.g., odor, noise, toxic water, etc.) should decline as distance from the landfill increases.

Furthermore, many of the potential problems associated with a landfill relate to negative externalities such as odor, toxic water, and methane gas which are particularly troublesome when found in concentrated amounts. The volume of air and land surrounding the landfill should act to absorb at least some of these externalities and reduce their nuisance effect. Doubling the distance from a landfill increases the cubic volume of air surrounding the landfill by a factor of eight and increases the land area by a factor of four. Thus, the negative effect of a landfill could decline exponentially as distance increases.

Methodology

The current study estimates the impact of municipal landfills on real estate prices using two different approaches: an event-study approach is used to estimate the impact on a before-and-after comparison basis, and multiple regression techniques are employed to quantify the impact of proximity to the landfill. The study was conducted in two phases which involved both primary and secondary data analysis.

To obtain the views of knowledgeable homeowners regarding potential landfill effects, a questionnaire was distributed to 900 residents living near five sanitary landfills. The intent of the survey was not to make inferences that could be generalized to the entire population of homeowners but to identify the attitudes and concerns of homeowners having first-hand knowledge of potential landfill effects. The questionnaire requested information regarding the resident's proximity to the landfill and an assessment of any health or nuisance effects associated with the landfill. The survey also asked for information regarding the age, purchase price, and estimated market value of the respondent's home. In addition, the respondent was asked to provide his/her perception of the impact of the landfill in the immediate housing market.

To provide a suitable sample size, the survey data was aggregated across all five landfills. Approximately, 25% of the questionnaires were completed and returned. The reader should be alert to the fact that there may be some degree of non-response bias in the results since individuals who are unhappy about an issue are more likely to respond. Alternatively, some respondents may have chosen to purposely understate their true concerns as part of a continuing effort to minimize the market's perception of the problem. In this case these two sources of bias work to offset one another. In fact, the survey generated both neutral as well as negative views which indicates a balanced response. Furthermore, since the objective of the survey is more exploratory than inferential, the impact of any residual non-response or intentional bias is less crucial.

To substantiate the survey results, data on market prices and detailed housing characteristics for sales surrounding five landfills were obtained for the 1985–1989 period. Market transaction data on homes sold within one mile of the landfill were obtained. While a one-mile limit is somewhat arbitrary it was felt that given the heterogeneous and highly industrialized nature of Cuyahoga county, extending the study area beyond one mile would take in such a variety of extraneous factors as to make the accurate assessment of the potential impact of landfills extremely difficult, if not impossible.

The effects of a landfill are not expected to be uniformly circular since a host of factors, such as weather conditions (primarily wind direction), truck traffic, and the quality of landfill management, combine to determine the ultimate direction and extent of any potential landfill effect. Since reliable information regarding many of these factors was not available, the concentric circle approach was initially adopted and later discarded in favor of more localized impact areas. Parcel numbers were used to assign each housing transaction to a small geographic area, typically covering only several blocks. The distance from the center of each housing area to the center of the landfill was then measured.

To estimate a potential landfill effect, multiple regression models were estimated for each of the five landfills. As previously mentioned, many factors beside proximity to a landfill will effect housing prices. For example, differences in age, size, style, and date-of-sale will often have a significant impact upon selling prices. The use of multiple regression allows the researcher to account for many of these non-landfill factors. By including a number of important housing characteristics in the model in addition to the distance-from-landfill variable, one is able to separately measure the impact of the landfill alone, holding the effect of these other factors constant. To illustrate, let the following linear equation represent a multiple regression model to estimate housing prices.

$$P = b_o + b_1X_1 + b_2X_2 + \ . \ . \ . \ + b_nX_n + b_mLF + e,$$

where,

P = the sales price of the house;
b_o = a constant term that summarizes the impact of variables not included in the model;
$b_1 \ldots b_n$ = the marginal value of certain housing characteristics, such as, size or age,
b_m = the marginal impact of distance to the landfill measured in miles (LF);
e = a random error term.

If the explanatory variables in the model are highly correlated (multicollinearity) the reported regression coefficients may be severely distorted. Variance inflation factors and condition indices recommended by Belsley, Kuh and Welsch [2] were used to test for multicollinearity which turned out not to be a major problem.[1]

To test whether or not the positive price gradient might be nonlinear, a log-linear version of the model was estimated. Since the results were quite comparable to the more straightforward linear model, the study reports only the linear multiple regression results. (See Kang and Reichert [11] for a more detailed discussion of optimal function form in appraisal models, and Reichert and Moore [23] for a more thorough discussion of multicollinearity.) Finally, only one of the five landfills began operations during the 1985–89 estimation period. The Jennings Road landfill was opened in March 1986 and thus allows one to make a before-and-after comparison.

Study Sample and Data

Information on real estate transaction prices and detailed property characteristics for residential properties were provided by the Cuyahoga county (Cleveland area) auditor's and the assessor's office over the past fifteen years. Approximately 15,000 residential transactions take place each year. Ten landfills are registered in Cuyahoga county. Each of these facilities was visited to determine such characteristics as physical size, volume of activity, length of operation, and any unique management practices. Five study sites were selected based upon their proximity to residential areas. The annual processed waste tonnage at various landfills ranged from a low of 7,000 tons per year to a maximum of 46,500 tons per year. The number of sales within a one-mile radius of the landfills ranged from 110 to 963 over the five-year period. A brief description of the two landfills reported in this study are included in endnote.[2] (Statistical results for each of the remaining three landfills are available upon request.)

Homeowner Survey Results

Homeowners living near the landfill were asked to evaluate potential health and nuisance problems on a scale of 1 to 5, where a rating of 1 indicates that the character-

Exhibit 1
Homeowner Evaluation of Landfill Impact

Panel A—Potential Nuisance and Health Problems

	Not a Problem				A Major Problem	Mean Rating Value
Characteristic:	1	2	3	4	5	
A. Unattractive	36.8	12.0	13.9	14.8	22.5	2.74
B. Odor	39.3	10.7	10.2	14.1	25.7	2.76
C. Noise	36.8	12.0	19.6	12.9	18.7	2.65
D. Truck traffic	43.8	12.5	17.8	9.6	16.3	2.42
E. Blowing trash	57.3	11.6	12.1	9.5	9.5	2.03
F. Health hazards:						
(a) methane gas	46.4	9.5	11.3	11.9	20.8	2.51
(b) toxic water	44.6	9.5	11.3	11.9	22.6	2.58
(c) rodents	44.9	12.4	13.5	11.8	17.4	2.44

Panel B—Economic Impact on Housing Market

	No Impact				Large Negative Impact	Mean Rating Value
Characteristic:	1	2	3	4	5	
Marketability	38.0	151	18.0	14.1	14.6	2.52
Homeowner flight	50.0	18.8	14.4	9.4	7.4	2.05
Selling price	41.1	15.3	14.4	12.9	16.3	2.48

Note: Table values are percentages; mean ratings are absolute numbers.
Source: analysis of author's survey data

istic is not a concern, while a rating of 5 indicates that, in their opinion, the characteristic represents a major problem. Ratings in between indicate a problem of varying degree.

Health and Nuisance Impacts

The results are reported in Panel A of Exhibit 1. To simplify the discussion, the two worst rating categories are combined to indicate when the factor is truly a significant problem. Among potential nuisances, odor appears to be the most significant problem as mentioned by 39.8% of the respondents, followed closely by unattractiveness (37.3%). Blowing trash and truck noise appears to be the least significant problems. In terms of potential health hazards, toxic water run-off was mentioned by 34.5% of the respondents, 32.7% mentioned methane gas, while 29.2% indicated that rodents were a significant problem.

To estimate the aggregate effect of these nuisances and health hazards, several indices were created. For a given respondent, numerical scores were summed over two subsets of problem characteristics. The Nuisance Index represents the aggregate score for the

Exhibit 2
Relationship between Landfill Impact Indices and Housing Market Characteristics

	Distance		Estimated Price		Rate of Appreciation	
Index:	Corr.	Prob.	Corr.	Prob.	Corr.	Prob.
Nuisance	−.11	.069	.23	.00	−.11	.074
Health	.05	.233	.33	.00	.04	.300
Total	−.06	.198	.28	.00	−.10	.097

Source: analysis of author's survey data

following characteristics: unattractiveness, odor, noise, truck traffic, and blowing trash. Thus, for each respondent, the aggregate score can range from 0 to 25. In a similar fashion, a Health Hazard Index was computed which included methane gas, toxic water run-off, and rodents. The Health Hazard Index can assume values from 0 to 15. A Total Impact Index was then computed that included both the Nuisance and Health Hazard Indices, and can assume values between 0 and 45 (note: an "Other" problem category was also included in the Total Impact Index.)

Homeowners were also asked to estimate how close their property was to the nearest portion of the landfill as measured in feet. In addition, respondents were asked to estimate the current market value of their home and provide information regarding the purchase price, date of purchase, and the value of any major additions to their property. From this information it was possible to estimate the average annual rate of price appreciation adjusted for the value of major additions. Exhibit 2 summarizes the correlation between distance from the landfill, current market prices, and average annual appreciation rates with each of the three indices. Since one can infer a likely directional impact, the one-tail level of significance is reported.

The data indicates that the correlation between distance and the Nuisance Index is significant at the 10% level, providing limited support for the attitude gradient hypothesis (i.e., as distance from the landfill increases, homeowner attitudes improve as reflected in a decline in the value of the nuisance index). On the other hand, all three indices are highly significant and positively correlated with an estimate of current market price. This suggests that residents owning more expensive homes are apparently more sensitive to these nuisance and potential health factors.

One would also expect that proximity to a landfill might reduce the rate of price appreciation over an extended period of time. Once again the nuisance factor is negatively correlated with appreciation rates at the 10% level of significance. In general, the nuisance factors appear to have the most consistent impact. This may possibly be attributed to the fact that characteristics such as odor, unattractivenes, noise, etc. are more readily observable than health factors such as methane gas and toxic water.

As reported in Exhibit 1—Panel B, respondents were asked to evaluate the impact of the landfill upon the price and marketability of houses in their area. Marketability refers to how easy (or difficult) a house is to sell at a reasonable price. In extreme cases,

Exhibit 3
Annual Appreciation Rate Grouped by Extent of Problem

Type of Market Impact	Major Problem	Not Major Problem	Rate Diff.	Stat. Sig.
Marketability	.054	.070	.016	.01
Homeowner Flight	.049	.069	.020	.01
Negative Price Impact	.058	.069	.011	.04

Source: analysis of author's survey data

homeowners may be induced to sell to avoid the landfill when otherwise they would like to remain in the area (homeowner "flight"). Approximately 29% of the respondents felt that the landfill had a significant negative impact upon selling price, followed closely by 28.7% who felt that proximity to a landfill significantly reduced the marketability of their property. Just under 17% felt that the problem was severe enough to induce homeowner flight.

To test whether or not the market's perception had a statistically significant impact on appreciation rates, respondents were divided into two groups: those indicating that marketability, homeowner flight, and selling price are major problems (e.g., ratings 4 and 5) and those giving these factors a lower rating. A t-test on the mean difference in appreciation rates between the two groups was conducted. One-tail tests of significance are reported in Exhibit 3.

As expected, the estimated average annual appreciation rates for homeowners who indicated that the landfill has had a major impact upon the local housing market were consistently lower than for the remaining homeowners. For example, the average annual appreciation rate for homeowners indicating that the landfill had a major impact on marketability was only 5.4% compared to 7.0% for the others. This represents almost a 30% difference in appreciation rates when measured in relative terms and was statistically significant at the 1% level.

Sales Price Analysis

The previous section dealt with homeowners perceptions of landfill problems and their potential impact upon the housing market. This section develops an hedonic regression model based upon actual housing prices (PRICE) and a detailed breakdown of housing characteristics. Appraisal theory indicates that basic major structural factors such as size, number of bedrooms and baths, and functional obsolescence as well as physical depreciation affect housing values. In models such as hedonic price equations which assume efficient housing markets, prices should reflect the marginal utility of key housing characteristics. While housing preferences change over time, most homeowners (within reason) prefer homes with more living space, larger lots, and value the privacy afforded by more bedrooms and baths. Thus, space, privacy, convenience, as well as various housing amenities such as air conditioning and the presence of a fireplace belong in the average housing utility function, and hence should be included as explanatory variables in an hedonic price model.

While utility theory is not sufficiently well developed to identify the precise definition of all the variables, a wide range of statistical studies have documented the importance of a consistent set of housing characteristics effectively employed in hedonic appraisal models (Gloudemans and Miller [6]; Wood [26]; Lang and Jones [13]; Bryan and Colwell [3]; Mark [15]; Morton [20]; Kang and Reichert [11]; Kohlhase [12]). The variables included in the current model are drawn from the recent empirical literature and generally conform to current appraisal practice. The set of regressors include the following continuous variables: total square footage of living area (*SQFEET*), square footage of garage space (*GARGE*), square footage of the lot (*LOT*), age of the house in years (*AGE*), total number of baths (*BTHS*), and distance from the landfill measured in miles (*DIST*). Since the sample includes housing transactions recorded over a five-year period it is necessary to adjust the results for inflation. To make this adjustment, a time variable (*TIME*) was included whose value runs from 1 to 60, reflecting the sixty months between January 1985 and December 1989. The regression coefficient on the *TIME* variable represents an average rate of monthly appreciation over the sample period (see Mark and Goldberg [16] for a discussion of alternative time indices).

In addition, a number of housing amenities are included as dummy variables in the model. Their presence is indicated with a 1 and a 0 for their absence. These variables include central air conditioning (*AIR*), full-basement (*BSMT*), above-average construction quality (*QUAL*), fireplace (*FIREPL*), and housing style (*RANCH*, *SPLIT* for split or bi-level, *BUNG* for bungalow; the base style is *COLONIAL*).

Aggregate Model

A pooled cross-sectional model was initially estimated across all five landfills over a five-year period. A dummy variable was used to account for differences associated with each unique landfill (results not reported). Most of the variables were statistically significant, carried the expected sign, and appeared to be of reasonable size. The one surprise was the *DIST* variable where the coefficient was estimated to be −$12,850. This indicates that housing prices decline by $12,850 for each mile one travels away from the landfill. This result is opposite what one would anticipate assuming a significant negative landfill effect. One problem that may be affecting the results is the fact that the nature of the housing market can change dramatically over relatively short distances. For example, a comparison of mean housing values indicates that there is a decline of about $7,000 in the average selling price as one moves one mile out from the landfill.

Estimating a pooled model across all five landfills introduces an unnecessary degree of cross-sectional variation into the sample. For example, Michaels and Smith [19] found that disaggregating a sample into four distinct submarkets characterized as ranging from below average to premier in terms of housing and neighborhood quality, significantly improved the reliability of the estimated results. The authors used the Tiao-Goldberg statistic to test for equality of the regression results among the four models. Virtually all of the explanatory variables reported unique housing prices effects across the four submarkets. Motivated by the improved submarket results reported by Michael and Smith, separate hedonic models were estimated for each landfill in the current study.

Only the results from the two landfills that generated statistically significant findings are discussed below. The results from the other three landfills are integrated into the conclusion section.

Jennings Road Landfill

The Jennings Road landfill began operation during March 1986. As suggested by Michaels and Smith, it is possible that the commencement of landfill operations may have a delayed impact upon housing prices. To test for this possibility a dummy variable (*AFTERONE*) was included that identifies sales that took place at least one year after the commencement of operations. Exhibit 4 reports the regression results for the Jennings Road landfill.

The model produced an *R*-square of 50.5%, an *F*-value of 64.4, and ten statistically significant variables with the expected sign and of reasonable size (*BSMT, QUAL, FIREPL, GARGE, SQFEET, LOT, AGE DIST, TIME, AFTERONE*). For example, the coefficient on basement (*BSMT*) is $8,604, the hedonic price for a fireplace (*FIREPL*) is $5,231, and the estimated annual rate of depreciation is −$284. The distance-from-the-landfill variable (*DIST*) once again carried a statistically significant negative coefficient of −$8,813. On the other hand, as expected, the coefficient on the dummy variable that divides the time period (*AFTERONE*) carried a negative and statistically significant coefficient of −$2,924. This value represents 6.1% of the average housing price in the area. The negative coefficient on *DIST* can possibly be explained by the fact that average housing values decline by about $14,000 as one moves out one mile from the landfill ($55,713 vs. $41,702).

Westlake Landfill

Exhibit 5 reports the results of the regression for the Westlake landfill. The model produced an *R*-square of 69%, an *F*-value of 89.2, and seven significant variables (*AIR, BSMT, SQFEET, TIME, BTHS, RANCH,* and *BUNG*). The coefficient on *DIST* while negative (−$971) was not statistically significant.

Taken together these results are somewhat disappointing. Neither approach to modelling the impact of distance to the landfill produced logical and consistent results. In only one case, the Jennings Road facility, was a significant negative landfill effect observed, and this related more to the beginning of operations rather than distance. A circle with a radius of one mile has an area of approximately 3.14 square miles. This can encompass a wide range of topographies, demographics, and housing structures. As previously mentioned, the area surrounding each landfill is unique. For example, the north rim of the study area for Westlake touches Lake Erie, while the east rim of the study area for the Jennings Road landfill is primarily an industrial parkway. In fact, for several of the landfills the housing closest to the landfill is the most homogeneous. As one moves out from these landfills the variety of housing increases and in many cases substantial declines in quality and value are noted. The housing characteristic variables in the model should adjust for some of these differences but perhaps not all of them.

Exhibit 4
Jennings Landfill Regression Results: *DIST* Variables

Stepwise Regression to Predict: PRICE

Variable	Variable List—Descriptive Statistics Mean	Std. Dev.
PRICE	48265.64	13459.00
AIR	.01	.13
BSMT	.95	.19
QUAL	.03	.19
FIREPL	.15	.35
GARGE	349.26	170.29
SQFEET	1323.18	382.92
LOT	5944.58	3172.76
AGE	52.79	20.20
DIST	.62	.20
TIME	31.72	16.87
BTHS	1.27	.45
RANCH	.15	.36
SPLIT	.03	.17
BUNG	.30	.46
AFTERONE	.59	.49

Regression Statistics

Coefficient of multiple determination	= .505
Coefficient of multiple correlation	= .710
Standard error of multiple estimate	= 9543.42
F-Ratio	= 64.4228
Degrees of freedom	= 15 & 947
Probability of chance	= .0000
Number of valid cases	= 963
Number of missing cases	= 2
Response percent	= 99.79%

Var.	Coeff.	Regression Coefficients *Beta*	*F*-ratio	Prob.	Std. Error
AIR	1046.70	.0108	.20	.647	2285.50
BSMT	8604.37	.1261	19.45	.000	1950.98
QUAL	12005.19	.1715	50.41	.000	1690.74
FIREPL	5230.88	.1391	33.10	.000	909.17
GARGE	9.45	.1196	24.26	.000	1.91
SQFEET	9.00	.2563	59.91	.000	1.16
LOT	.55	.1309	26.98	.000	.10
AGE	−283.97	−.4262	172.24	.000	21.63
DIST	−8812.62	−.1330	29.38	.000	1625.77
TIME	279.91	.3509	64.15	.000	34.94
BTHS	1211.39	.0413	2.16	.141	822.54
RANCH	−486.85	−.0132	.14	.705	1287.02
SPLIT	2451.25	.0317	1.03	.039	2409.07
BUNG	−355.94	−.0122	.20	.650	785.50
AFTERONE	−2923.80	−.1067	5.93	.015	1200.21
Const.	32104.89		174.57	.000	2429.82

Source: analysis of author's survey data

Exhibit 5
Westlake Landfill Regression Results: *DIST* Variables

Stepwise Regression to Predict: PRICE

Variable	Variable List—Descriptive Statistics Mean	Std. Dev.
PRICE	112112.34	50087.05
AIR	.37	.48
BSMT	.84	.35
QUAL	.66	.47
FIREPL	.63	.48
GARGE	437.62	124.05
SQFEET	1921.45	685.65
LOT	15594.03	9795.24
AGE	28.55	17.05
DIST	.70	.20
TIME	27.75	16.62
BTHS	2.17	.87
RANCH	.29	.45
SPLIT	.07	.26
BUNG	.22	.42

Regression Statistics

Coefficient of multiple determination = .691
Coefficient of multiple correlation = .831
Standard error of multiple estimate = 28187.20

F-Ratio = 89.1504
Degrees of freedom = 15 & 558
Probability of chance = .0000

Number of valid cases = 573
Number of missing cases = 15
Response percent = 97.45%

Var.	Coeff.	Regression Coefficients *Beta*	*F*-ratio	Prob.	Std. Error
AIR	5880.04	.0569	3.68	.055	3064.62
BSMT	15017.31	.1072	16.63	.000	3681.65
QUAL	−2827.74	−.0266	.55	.457	3801.95
FIREPL	−1602.78	−.0154	.29	.598	2967.19
GARGE	19.88	.0492	2.53	.111	12.47
SQFEET	44.59	.6015	206.40	.000	3.10
LOT	.03	.0077	.07	.777	.13
AGE	−64.03	−.0218	.43	.510	97.25
DIST	−970.73	−.0040	.02	.877	6301.63
TIME	658.75	.2186	84.28	.000	71.75
BTHS	8738.74	.1526	10.99	.001	2635.50
RANCH	6356.11	.0578	2.87	.090	3749.55
SPLIT	−6144.09	−.0330	1.57	.210	4898.20
BUNG	−8304.70	−.0697	5.23	.022	3631.31
Const.	−29193.64		13.14	.000	8053.60

Source: analysis of author's survey data

In an effort to define a more homogeneous Westlake sample, a smaller region just north of the landfill was selected. Here the landfill is separated from an expensive residential community (Bay Village) by an active set of railroad tracks. Thus, houses located directly north of the landfill are subject to both a potential landfill and a railroad effect. A dummy variable was included in the model to measure the combined impact of the landfill and the railroad (*LF&RR*). To help separate the two effects, it was noted that houses located near the far northwest and northeast corners of the landfill and adjacent to the railroad tract are primarily subject to a railroad effect. A second dummy variable (*RR*) was included to measure this "pure" railroad effect. One would expect the absolute value of the coefficient on *LF&RR* to exceed the coefficient on *RR*. In fact, the difference between the two coefficients (*LF&RR*–*RR*) would represent the landfill effect.

As indicated in Exhibit 6, approximately 19.2% of the 375 housing transactions in the reduced model are subject to both the railroad and landfill effects, while 22.4% of the housing sales fall in the pure railroad effect areas. Reflecting a more homogeneous market area, the model's *R*-square increased to almost 80%. Eight variables are statistically significant and carry the expected sign (*AIR*, *BSMT*, *SQFEET*, *AGE*, *TIME*, *BUNG*, *LF&RR*, and *RR*). Both the *LF&RR* and *RR* variables are negative and, as anticipated, the absolute value of the coefficient on *LF&RR* exceeds the coefficient on *RR* ($12,787 vs. $6,722). This difference of $6,065 can reasonably be attributed to the landfill. This represents a decline of 5.5% compared to the average selling price of $108,786, which is generally consistent with the −6.1% impact reported in the Jennings Road landfill results.

Conclusions

The survey of homeowners living near landfills indicates that the most severe nuisances are odor and unattractiveness which were reported by about 40% of the respondents. Toxic water run-off and methane gas were mentioned by approximately 35% of the respondents as the most severe health issues. Not surprisingly, the farther from the landfill, the weaker the impact of the nuisance factors. A strong correlation was found between the respondent's estimated market price and both nuisance and health indices. This suggests that homeowners who own more expensive homes are more sensitive to landfill problems. Furthermore, the nuisance factors appear to have a weak negative impact upon estimated appreciation rates. Almost 30% of the respondents felt that the landfill had a severe adverse impact on selling price and marketability, while 17% felt the landfill could induce homeowner flight. Both nuisance and potential health problems are perceived to be related to a reduced level of marketability, lower selling prices, and increased homeowner flight. Furthermore, lower average annual appreciation rates are associated with reduced marketability, lower selling prices, and homeowner flight.

A total of 2243 market sales located near the five landfills were analyzed. The results are somewhat mixed as the current literature suggests. For example, the negative coefficient (−$2,924) associated with the dummy variable that marks the one-year anniversary of the opening of the Jennings Road landfill, suggests that the facility may have reduced property values by an average of 6.1%. On the other hand, when a circular area of about three square miles is used as the study region and proximity to the landfill

Exhibit 6
Westlake Landfill Regression Results: *LF&RR* Variables

Stepwise Regression to Predict: PRICE

Variable	Variable List—Descriptive Statistics Mean	Std. Dev.
PRICE	108786.53	46220.68
AIR	.33	.47
BSMT	.83	.36
QUAL	.69	.46
FIREPL	.62	.48
GARGE	429.42	121.24
SQFEET	1869.80	654.98
LOT	14012.94	5715.68
AGE	27.47	12.77
TIME	28.67	17.14
BTHS	2.19	.87
RANCH	.30	.46
SPLIT	.06	.25
BUNG	.24	.43
LF&RR	.19	.39
RR	.22	.41

Regression Statistics

Coefficient of multiple determination	= .795
Coefficient of multiple correlation	= .891
Standard error of multiple estimate	= 21360.24
F-Ratio	= 92.8123
Degrees of freedom	= 15 & 359
Probability of chance	= .0000
Number of valid cases	= 375
Number of missing cases	= 1
Response percent	= 99.73%

Var.	Coeff.	Regression Coefficients *Beta*	*F*-ratio	Prob.	Std. Error
AIR	7743.58	.0792	7.79	.005	2772.68
BSMT	11296.02	.0903	10.14	.001	3546.87
QUAL	−4052.00	−.0406	1.14	.284	3780.12
FIREPL	2610.62	.0274	.83	.360	2848.89
GARGE	17.47	.0458	1.88	.170	12.73
SQFEET	46.51	6591	206.97	.000	3.23
LOT	−.14	−.0174	.33	.565	.24
AGE	−455.53	−.1259	11.95	.000	131.75
TIME	708.07	.2626	112.10	.000	66.87
BTHS	3235.97	.0612	1.47	.224	2661.14
RANCH	2793.98	.0279	.58	.445	3659.47
SPLIT	−5597.05	−.0308	1.24	.266	5023.96
BUNG	−8843.43	−.0827	5.88	.015	3646.76
LF&RR	−12787.89	−.1091	13.33	.000	3501.49
RR	−6722.11	−.0607	3.98	.046	3366.70
Const.	−3808.51		.31	.573	6751.68

Source: analysis of author's survey data

is measured in miles, counter-intuitive results are obtained in four of the five regions. That is, as distance from the landfill increases market values decline, or alternatively, the closer to the landfill the greater the average market value.

At first glance these results might suggest a positive landfill effect but only a few of the survey respondents specifically identified positive aspects of living near a landfill. Furthermore, the size and quality of housing and the nature of the terrain can change dramatically within a relatively short distance. These factors can have a significant impact upon housing prices. While appraisal theory can identify a sizeable number of key housing price determinants such as those included in the current models, data limitations may make it impossible to model all possible factors.

In an effort to reduce the heterogeneous nature of the housing market, two landfills were selected for more careful study. The study areas were reduced to a more a homogeneous region immediately surrounding the landfill. In only the Westlake landfill was a negative and statistically significant result observed. Limiting the analysis to a 15–18 block area running parallel to the landfill suggests an average $6,000 negative landfill effect. For housing within sight of the landfill the average negative landfill impact increases to approximately $8,000. These findings suggest a 5.5% to 7.3% impact upon average housing values and are generally consistent with the McClelland, Schulze and Hurd results where property values in an equally expensive housing market were approximately 7.2% lower due to a hazardous waste landfill. Since none of the landfills in the current study accept hazardous waste, it seems logical that the McClelland, Schulze and Hurd findings would be towards the upper end of the impact range for sanitary (nonhazardous) waste sites. In the Jennings Road and Brooklyn landfills a weaker negative impact of between 3%–4% was observed.

It is perhaps not surprising that the strongest negative impact was observed in the Westlake area that has by far the most expensive housing located immediately north of the landfill. This southern edge of Bay Village is a quite homogeneous, high income area with large, relatively new homes owned by a mix of young and middle-age families. For several of the other landfills, the surrounding housing stock is generally smaller, less expensive, and often owned by older residents near retirement age.

Thus, this study concludes that landfills will likely have an adverse impact upon housing values when the landfill is located within several blocks of an expensive housing area. The negative impact is between 5.5%–7.3% of market value depending upon the actual distance from the landfill. For less expensive, older areas the landfill effect is considerably less pronounced, ranging from 3%–4%, and essentially nonexistent for predominantly rural areas.

Notes

[1]Two measures of multicollinearity were calculated; variance inflation factors (VIFs) for each independent variable and condition indices suggested by Belsley, Kuh and Welsch. The largest VIF for the Jennings landfill model was only 2.4 and the largest value for the Westlake landfill model was 4.5. In neither case did the condition indices exceed a value of 30 with at least two variance proportions in excess of 0.5.

[2]The Jennings Road landfill processes only construction materials, such as lumber and bricks. The site is surrounded on three sides by homes of various types that generally fall in the low to

moderate price range, while to the east lies an industrial parkway. The area northeast of the landfill is highly industrialized with a large manufacturing plant dominating the region. The Jennings landfill facility was opened in 1986 and appears to process a relatively low volume of trash. According to local residents, prior to commencement of operations the present site of the landfill was an unregulated open area that was frequently used as an illegal dumping area and for unsupervised recreational activity. The one-mile study area included 963 sales during the five-year estimation period.

The Westlake landfill is located in the northern part of the city of Westlake along the Bay Village border. An active Norfolk & Western railroad track runs along the north side of the landfill. Expensive residential properties exist along the Bay Village side, while less expensive homes surround the landfill on the remaining three sides. South of the landfill is a significant commercial park development, while to the east and southeast of the landfill are apartments, condominiums, retirement facilities, and a few single-family homes. The landfill commenced operations in 1958 and closed in May 1990. Most of the expensive residential development just north of the landfill in Bay Village took place after the landfill began operations. A section of the landfill that has been closed for several years has been landscaped and is being used for recreation purposes. One portion of the landfill is now being used for a leaf composting project. When the landfill was active it processed waste from the city of Westlake only. The landfill was closed after significant public protests arose regarding potential environmental and health hazards from local residents and a perceived negative impact upon home values from residents in Bay Village. The one-mile study area included 586 sales during the five-year estimation period.

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