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The Effects of Environmental Contamination on Real Estate: A Literature Review

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Abstract

The literature reviewed in this article reflects the degree to which practitioners and academics are having difficulty in arriving at consistent findings as to the effect of environmental contamination on real estate. The valuation literature in this category deals with appraisal methods, but does not develop a consensus view. The empirical sales price literature is also inconsistent, with disagreement over the existence and magnitude of price impacts, persistence of these impacts and other issues. The article concludes by summarizing the results of these studies with respect to contamination source, effect on sales price, persistence and intervening factors such as strong or weak market conditions.

Introduction

The literature on the effects of environmental contamination on real estate may be divided into two general categories. The first category involves contaminated property valuation concepts and methods. This literature is largely drawn from the appraisal profession, and addresses the notions of stigma, risk and how contamination affects the market value of real property. Most of this literature has focused on defining appropriate methods for valuing contaminated property that recognize the unique risks associated with this property type. Also, the literature in this category is primarily applicable to income-producing, commercial and industrial real estate. To date, however, the valuation literature has offered few empirical studies of contaminated real estate, but rather has focused on how existing appraisal methods can be adapted to estimate the impacts of contamination on market value.

The second literature category presents empirical studies on the effects of contamination and other negative environmental externalities on real estate prices. Studies in this category can be divided into those dealing with the effects of contamination on residential real estate and studies on commercial and industrial real estate. The residential real estate literature is research that is primarily concerned with situations in which the impacted properties are not the source of the contamination, but are affected by contamination generated from other sources and properties. This literature serves as a useful comparison to commercial and industrial property impacts, and also provides important insights into the changes in adverse effects before and after remediation or cessation of the negative externality. This generally well-

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developed literature has evaluated impacts ranging from radioactive waste releases to the announcement of hazardous landfill sitings.

There is a more limited amount of empirical research on the effects of contamination on commercial and industrial properties. Although there have been a number of articles in *The Appraisal Journal* and elsewhere that discuss valuation methods for contaminated properties, relatively few published studies have been based on the empirical analyses of sales data. One reason for the lack of empirical research, especially in comparison to the residential property studies, is that contaminated commercial and industrial properties have only recently begun to sell with any frequency. As discussed in the some of the literature, in the past the risks perceived by market participants were such that equity and debt capital were generally unavailable for contaminated properties. This situation appears to be changing, and sales data is becoming more available. However, most of the literature reviewed in this category is largely based on a few case studies, rather than on the type of systematic analysis found in the residential studies.

Contaminated Property Valuation

As noted, the first literature category focuses on the concepts and methodology for valuing contaminated property and estimating the effects of contamination on market value. Patchin (1988) laid out the first framework for valuing contaminated real estate. Patchin's framework focused on clean-up costs, the availability of indemnities, equity yield rates and risk premiums, and the costs of financing. The valuation tool recommended by Patchin was income capitalization with the Ellwood method for deriving capitalization rates. The Ellwood method is dependent on the equity yield rate, available mortgage terms and anticipated future appreciation or depreciation. Patchin noted that there was ''virtually no chance of obtaining mortgage financing for a seriously contaminated property.'' Thus, the valuation focus would be on the equity requirement in the Ellwood mortgage-equity framework. The lack of market data and sales involving contaminated real estate at that time further underscored the reliance on the income capitalization approach, rather than a sales comparison based approach.

Subsequently, Patchin (1991) revisits his earlier work and focuses on the concept of ''stigma'' as it applies to contaminated property. Patchin notes that property value can be reduced by the perception that a contamination hazard exists ''whether the market perception is rational or not.'' Patchin attempts to delineate the factors that contribute to these perceptions known as stigma. The first is the ''fear of hidden clean-up costs,'' that affect a property's marketability and value prior to completion of required remedial activities. Patchin also suggests that even after cleanup, there may be ''market resistance,'' and this could lower value. Another element is termed ''the trouble factor,'' and corresponds to the ''trouble'' of making the necessary remedial improvements that would not be required with an uncontaminated property.

According to Patchin (1991), there can be a decline on market value for a contaminated property that is beyond, or in addition to, the cost to cure, even when the cost to cure is well defined. It is this additional decline that later writers have

termed the stigma effect (Mundy, 1992a,b,c; Chalmers and Jackson, 1996; and Jackson, 1998). Patchin's other factors are the ''fear of public liability'' and the ''lack of mortgageability.'' Public liability fears would be related to the possibility of third party litigation against a future owner. As for the lack of mortgageability, Patchin asserts that ''the inability to obtain financing, either for the sale of a property or its future financing, is one of the most frequent causes of stigma related value loss.'' Lastly, Patchin compares commercial properties to residential properties by arguing that once the environmental issue is cured, stigma for residential properties disappears. Patchin does not ascribe the same pattern to contaminated commercial properties, though. Patchin offers a few anecdotal examples to support these assertions.

About the same period of time that Patchin produced his seminal articles, Rinaldi (1991) offered an overview of how appraisers could approach the valuation of contaminated property. The valuation of such properties, accordingly to Rinaldi, should be accomplished by first estimating the value of the property as if it were uncontaminated, and then analyzing the loss in value due to the contamination. This is sometimes referred to as the ''unimpaired value'' and the ''diminution in value.'' Rinaldi then suggests that the way to estimate the loss in value is to estimate and deduct remediation costs and any lost rental income attributable to the contamination. Rinaldi does not deal with the concept of stigma and the risk perception idea set forth by Patchin.

Dorchester (1991) addressed the responsibilities of the appraiser when faced with a contaminated property assignment. Dorchester's main point is that appraisers are not qualified to evaluate environmental problems and should clearly separate the valuation function from the work of environmental specialists. In Dorchester's view, appraisers must rely on qualified professionals in the environmental sciences, but not place themselves in that role.

Mundy (1992a,b,c) sets forth a conceptual and valuation framework that has influenced the appraisal profession. Reiterating the ideas of Patchin, Mundy (1992a) asserts that the ''value paradigm'' for contaminated property real estate damages is the difference between the value before, or ''clean,'' and the value after, or ''dirty.'' Mundy (1992a) goes on to note that from a mathematical perspective, the difference ought to be the cost to cure or remediate the property. However, Mundy notes that in practice this is not the case since contaminated properties sell for less than the cost to cure difference. Mundy ascribes this inconsistency to an additional effect on value termed stigma. Stigma in Mundy's framework is directly related to the level of uncertainty or risk associated with contamination which, in turn, is influenced by the amount of information the market has about the contamination and its remediation.

Building on this concept of stigma, Mundy (1992b) outlines a valuation approach that has two components: an ''income effect'' and a ''marketability effect.'' The income effect is related to the lost income that may result from the contamination. The effect of the contamination on value, or the resulting damages due to the income effect, would be measured by the discounted present value of the lost income. Lost income could occur as a result of a decrease in rent, a decrease in occupancy or an increase

in operating expenses (Mundy, 1992c). Mundy's marketability effect would account for the increased marketing period for the contaminated ''frozen'' asset. The measurement of this effect would be reflected in an increase in the discount period and the realization of income or other gains at a period further out into the future. Present value would be determined with a risk-adjusted discount rate.

Mundy (1992c) focuses on the determination of the risk-adjusted discount rate. Like Patchin, Mundy focuses on the potential increase to the cost of capital as an appropriate measure of the increased risks associated with contamination. The contamination risks, or stigma effect, would be reflected in the increased risks to the equity and debt positions, and accordingly result in an increased discount rate. However, while Patchin reflected increased risks in capitalization rates through the Ellwood approach, Mundy prefers an increase to the discount rate. Further, Mundy uses variable discount rates relative to the risk in each time period. The net cash flows for each period are then discounted to present value by a rate that corresponds to the risks associated with that period. Lastly, Mundy notes the lack of sales data to extract these rates and risk premiums, and recommends basing risk premiums on information obtained through interviews with investors and lenders in similar properties.

Neustein (1992) and Chalmers and Roehr (1993) reflect these same concepts. Neustein echoes Mundy by noting that the diminution in value due to contamination results from two factors: reduced net income and a risk premium rate adjustment. Instead of the risk premium applied to the discount rate, though, Neustein focuses on the capitalization rate and does not distinguish between debt and equity components. Further, Neustein demonstrates a technique whereby simple income ratios can be used in a direct capitalization formula rather than actual differences in net operating income. This allows Neustein to make a graduated set of comparisons of different capitalization rate premiums and income ratios in terms of their effect on value. This simplifies the problem, but may not allow for finer adjustments based on other variables. Chalmers and Roehr opt for a discounted cash flow (DCF) approach with multiple discount rates corresponding to the contamination related stigma risks for each year of the presumed holding period.[1] The underlying concept echoes the comments of Patchin and Mundy in that risk is not constant over the holding period. Indeed, these authors suggest that the effect of stigma and its risk premium may decline over the holding period and subsequent to remediation.

Wilson (1994, 1996) offers a cost based methodology for estimating the effects of contamination on value. Using similar concepts, Wilson (1994) stresses that the estimation of the value of a contaminated property must consider the ''negative impact of intangible factors.'' Among these factors are the general demand for the subject in the marketplace, the level of confidence in remediation cost estimates, the stability of regulatory decisions concerning the contamination and its cleanup, the availability of financing for the contaminated property and the possibility of third-party liabilities. In Wilson's framework, the quantified effect of these intangible factors is deducted from an unimpaired value, together with remediation costs and any quantifiable effect of use restrictions.[2] Wilson's brief consideration of market factors, as perhaps mitigating the effect of the contamination, is the first mention of this variable found

in the valuation literature. Market conditions would be an intervening variable between contamination and its effect on value and price. The potentially intervening effect of market conditions will also be considered in subsequent sections of this article.

Wilson (1996) presents these relationships in a formula that says that impaired value equals unimpaired value less all of the items just mentioned. Wilson does not elucidate the actual calculation of these items. Wilson equates stigma only to ''intangible market factors'' and not financing costs, which are treated as a separate deduction. This seemingly contradicts Patchin and Mundy, who equate increased financing costs to the effect of stigma. Patchin and Mundy explicitly consider the increased cost of debt as a direct measure of risks due to stigma through increases in capitalization and discount rates.

Chalmers and Jackson (1996) directly address the increased cost of debt and equity due to contamination in their valuation framework. In this framework, increases to the investor's required rate of return, or risk premiums, are used to compensate for the increased risks associated with contamination. Likewise, the lender's criteria, including the loan-to-value ratio, interest rate and amortization period, are adjusted to compensate for contamination risks. These risk adjustments account for the stigma effect and result in a lowered value relative to the value of a property in an uncontaminated state. These risk adjustments account for Wilson's intangible market factors and increased financing costs, although Wilson only ascribes stigma only to the intangible market factors component, and not increased financing costs.

Another concept set forth by Chalmers and Jackson (1996) involves the ''contamination lifecycle.'' Briefly, this lifecycle concept posits that contamination related risks are highest before cleanup, and then decline during cleanup and decline further on completion of the remedial activities. While also discussed by Mundy, Wilson and others, lifecycle effects are critical explanatory factors in the Chalmers and Jackson framework, as applied to contaminated commercial and industrial properties. Patchin (1991) discusses a diminishing stigma effect ''once the cure is actually in place,'' but only in relation to residential properties. Patchin suggests that commercial and residential properties are different in this regard.

Chalmers and Jackson (1996) focus on the perceptions of lenders and investors as being the appropriate variable influencing the effect of contamination on market value for commercial and industrial real estate. This is consistent with Mundy (1992b) who differentiates between real and perceived risks, with perceived risks having a key influence on value. Likewise, Patchin (1991) notes that market perceptions can influence value whether or not the perception is rational (fact based) or not. In Patchin's framework, stigma is a ''negative intangible.'' Since these early writings, the commercial and industrial real estate market has gained more knowledge and experience with contamination issues, and these perceptions should, arguably, be more rational. The point is that contamination is an unknown, especially before cleanup, and unknowns create uncertainty, which is tantamount to greater risk for investors and lenders in commercial and industrial real estate.

Roddewig (1996) also discusses stigma as a perception-based effect on value, and ''as an additional impact on value, over and above the cost of cleanup or remediation.'' Roddewig notes several ''cycles'' that affect contaminated real estate, including the ''remediation cycle.'' The remediation cycle concept to Roddewig is similar to that of Chalmers and Jackson (1996). According to Roddewig, over the remediation cycle, and as time passes, the market gets more information about the remediation, and the stigma effect gradually decreases. Roddewig does not state that the stigma effect goes away, or that there is a definable pattern to its decline, but rather that it would decline over the remediation cycle as more is known about the contamination, remediation requirements and costs.

Jackson (1997) lists a number of elements or factors that are important in estimating the impact of contamination on the value of income-producing property. These include: (1) the cost and timing of the remediation; (2) indemnifications; (3) certainty about the characterization of the nature and extent of the contamination; (4) potential for business interruption costs; (5) the existence of an approved remediation plan; (6) strength of the regulatory framework; and (7) the probability of third-party lawsuits. Items 1, 3 and 5 are related to the remediation lifecycle concept laid out by Chalmers and Jackson (1996). Item 2 is consistent with Patchin (1988), who discusses securing an indemnity as a key step in marketing a contaminated property. Item (4) is consistent with Mundy's (1992b) ''income effect.'' Although not mentioned above, Roddewig (1996) discusses a ''regulatory cycle,'' which would relate to Item (6). Item 7 also corresponds to Patchin's (1991) ''fear of public liability.''

In analyzing the effect of these factors, Jackson (1997) opts for a DCF model, and reflects the effect of the contamination in two ways: (1) remediation costs are deducted from income during the period in which they are projected to occur; and (2) an increase in the property's overall yield rate to account for the additional risk, or stigma, associated with the contamination. Based on interviews with contaminated property investors and recent transaction data, Jackson notes that ''risk premiums of 500 basis points are not uncommon.'' In the DCF model framework, Jackson capitalizes the terminal year income at an unimpaired rate, plus 50 basis points for additional non-environmental risk, under the assumption that the property's value would be relatively unaffected subsequent to remediation.

Jackson, Dobroski and Phillips (1997) discuss regulatory and market changes that have increased the marketability of contaminated real estate. These changes include the introduction of more flexible risk-based remediation standards that allow cleanup to levels specific to the future use of the property. For example, contaminated industrial property can, in many jurisdictions, be remediated to industrial standards rather than higher and more costly residential standards. These regulatory standards also recognize that low cost natural attenuation in many cases provides the same result as more expensive and intrusive technologies. In analyzing these factors, Jackson, Dobroski and Phillips use a modified DCF format that incorporates many of the elements of the Ellwood technique in arriving at a mortgage-equity analysis of the contamination-related financial risk adjustments. Without these modifications,

mortgage-equity analysis in a DCF framework can be accomplished but through a series of manual iterations.

Bell (1998) classifies ''detrimental conditions'' that effect real estate in ten categories. One of these categories is ''environmental conditions.'' The ''bell chart'' for the value effects of environmental conditions shows an initial drop in value and then a return to ''full value upon the assessment and repair of the condition.'' Bell uses the concept of ''market resistance'' as roughly equivalent to stigma. Bell ascribes market resistance to many of the same factors discussed by the previous authors, including the fear of future liabilities or hidden cleanup costs, and the ''general hassle or trouble factor'' of owning contaminated properties. Bell's methodologies for analyzing these properties include direct capitalization analysis, with risk-adjusted capitalization rates and income adjustments, similar to Mundy (1992b) and Chalmers and Jackson (1996), and market data analysis, which Bell (1998) demonstrates with an analysis of the value diminution indicated by ten contaminated property sales. In this analysis, Bell estimated the diminution by deducting the value contaminated, or the sales price, and buyer paid remediation costs from the value uncontaminated. The remaining value loss could be equated to the stigma effect. Lastly, Bell also mentions the use of DCF analysis. Assumedly, a risk-adjusted discount rate would be used in a manner similar to that set forth by Jackson (1997).

An approach to valuing contaminated land is offered by Weber (1997). Weber notes that contamination could have the effect of altering both the highest and best use of land as well as the time required to develop a site. Further, Weber echoes the reservations expressed by Patchin (1988), Wilson (1994, 1996) and Roddewig (1996) concerning the use of comparable sales to analyze the effects of contamination on real property. These reservations primarily relate to the property and site specific attributes of contamination, and the way they affect value. As an alternative, Weber proposes a development model with contamination risks analyzed through a Monte Carlo-based method. The contamination risks are attributed to potential variances in remediation costs, and the simulation assigns the likelihood to potential cost outcomes. Thus, risk attributes would be communicated as a probability distribution of potential outcomes with respect to remediation costs. Weber notes that the insurance industry uses a similar technique for calculating premiums for providing insurance on contaminated sites.

Another alternative method is offered by Lentz and Tse (1995), who propose the use of an options pricing model to estimate the value of contaminated income-producing real estate. Lentz and Tse view their proposed technique as an alternative to DCF analysis, which they refer to as the ''traditional approach'' to the valuation of contaminated and income-producing property. In the options pricing model proposed by Lentz and Tse, the owner of a contaminated property would have two options: to remove the contamination at the optimal time, and to redevelop the property to a higher and better use at the optimal time. Redevelopment plan options, having different cash flows and remediation costs, would not be exercised until the first option to clean up the site had been exercised. A central choice is whether to accelerate or

postpone development, based on the differences in cash flows and costs in the redevelopment plan options. In the Lentz and Tse framework, there are only two variables: free and clear cash flow of the property in its redeveloped state, and the redevelopment and remediation costs. Thus, their framework uses similar data to the other income-based approaches.

In a more traditional valuation context, Jackson (1998) argues in favor of the mortgage-equity approach, either through Ellwood or through a modified DCF approach, as the framework that is most useful for quantifying the effect of stigma-related risks. Risk quantification in Jackson's framework is based on the perceptions of market participants. The two key sets of participants would then be mortgage lenders and the equity investors, since they control the flow of capital available for real estate acquisition and development. According to Jackson, risk adjustments, as equity return premiums, increased mortgage interest rates, or reduced loan-to-value ratios, can be derived from the market through property and site-specific lender and investor surveys. These surveys gauge perceptions of risk by asking respondents about rates of return and loan criteria for a property assuming no contamination and then in its ''as is'' condition. Jackson's modified DCF model is a hybrid combining elements of the Ellwood formula and a DCF analysis. This allows for the explicit input of mortgage and equity criteria and adjustments as in the Ellwood approach, but also accommodates uneven cash flows through the DCF framework.

Lastly, Kinnard and Worzala (1999) present the results of a survey of appraisers on the methods that they use to value contaminated property. They begin, however, by recognizing that the recommended approach in the professional literature is income capitalization, with adjustments to the discount or capitalization rate to account for the perception of increased risks due to contamination. However, they differ with much of the previous literature with their concept of stigma as solely a post-remediation effect, rather than as an effect potentially operative before, during and after remediation.

Despite the recommendations in the professional literature, the Kinnard and Worzala (1999) survey shows that 80% of the responses ($n = 65$) use the sales comparison approach and 79% ($n = 64$) use the income capitalization approach when valuing contaminated property. The most frequent adjustment within the income capitalization approach is to increase the capitalization rate. Direct capitalization is preferred to DCF analysis. Although there is no data on this point, these results might reflect the general tendencies and preferences of appraisers, regardless of the property's environmental status. However, the results do seem at odds with the theme in most of the valuation literature, which emphasizes the income approach.

Sales Price Analyses

In reviewing the literature in this category, comparisons and contrasts will consider three questions: (1) whether or not the contamination had a measurable effect on price and value; (2) if there was an effect, was it temporary, or did it persist subsequent to remediation of the site or withdrawal of the disamenity; and (3) the existence of any

observed intervening conditions, such as a strong or weak market, that may have influenced the effects of the contamination on property prices and values. The literature on residential property sale price impacts is more extensive than the empirical studies of the impacts on commercial and industrial properties.

Residential Properties

One of the earliest studies of residential property impacts is by Gamble and Downing (1982), who analyzed the effects of the March 1979 Three Mile Island (TMI) nuclear accident on nearby residential properties. Gamble and Downing analyze the sales of 583 single-family houses within twenty-five miles of the nuclear power plant and 112 house sales in a control area seventy-five miles north of TMI over two time periods: two years (January 1977 to March 1979) before the accident and nine months after the accident. The critical variable in the Gamble and Downing multiple regression model is the distance to the plant. In the before period, the distance variable is significant and positive, indicating that property values increase as distance from the plant increases. After the accident, the distance variable is not significant, leading Gamble and Downing to conclude that the accident had no effect on price. However, Downing and Gamble note that the number of sales within ten miles of the plant declined immediately following the accident. They report that local Realtors® characterized this period as ''a virtual collapse of the market.'' However, after four to eight weeks, Gamble and Downing observe that sale volumes had returned nearly to their pre-accident levels. Thus, the effect in this highly publicized case was temporary, and primarily affected marketing time.

In a study of a perceived hazard, Colwell (1990) analyzes the effect of overhead power lines on residential property values. Colwell estimates the parameters of a sales price model using 200 sales, over the ten-year period from 1968 to 1978, from several study areas located within 400 feet of an overhead power line. Colwell analyzed these sales in a hedonic framework with the logarithm of price as a function of the physical characteristics of the properties, such as number of square feet of living area and number of bathrooms. The adjusted R^2 was .77. The model also included distance measures for each sales property from the power line. This proximity variable was positive and significant, indicating that prices increased with distance from the power lines. This distance approach was also used in the TMI analysis. A further analysis of the data by Colwell revealed that the proximity variables tended to decrease in significance over time, indicating that the adverse price effects diminished. Colwell speculates that this may be due to trees growing up to shield the power lines from view. Another explanation is that the market may simply become more comfortable with the power lines and perceived risks were diminished.

Another perspective is provided by McClelland, Schulze and Hurd (1990), who combine survey research on the health risks perceived by residents living near a landfill with a sales price model that estimates the effect on price of the risk beliefs of neighborhood residents. The authors begin with a survey of residents in neighborhoods surrounding a non-toxic landfill in California. The results show a bimodal pattern, with one group perceiving a high risk and another perceiving low

risks. The survey also showed that closing the landfill would significantly reduce these perceived risks. Interestingly, some variation in the risk belief pattern could be explained by demographic variables of age and sex, with younger people and women reporting higher perceived risks. The next steps in the study were to develop a hedonic model of sales price and then determine if the residents' risk perceptions have an independent and significant effect on price. Using aggregated risk beliefs by neighborhood, McClelland, Schultz and Hurd find that house prices decline as the proportion of neighborhood residents having ''high'' perceived risks increases, and further that this effect is statistically significant at the 0.05 level. A 10% increase in the proportion of high-risk perceivers corresponds to a $2,000 decline in house price, with average prices of $135,733. The researchers also study sales price effects after closure of the landfill, and conclude that adverse sales price impacts are reduced from an aggregate of $40.2 million before to a $19.7 million total price impact after closure for the 4,100 houses near the landfill. The importance of this research, though, is the linkage of the survey data with the price effects.

A seminal study of residential property impacts was conducted by Kohlhase (1991), who used data on thirteen Superfund sites in Houston to develop hedonic pricing models, with price as a function of the physical characteristics of the property as well as its distance from the hazardous site. The study found a significant reduction in price for houses closer to the hazardous sites after the designation of the sites on the Superfund list had been publicized by the U.S. Environmental Protection Agency (EPA). This effect was reduced or eliminated as distance increased, and subsequent to remediation, or clean up, of the hazardous sites. Thus, Kohlhase found an effect due to proximity, and determined that this effect was temporary. No evidence is presented with respect to intervening market conditions that may have otherwise increased or dampened the effects.

Thayer, Albers and Rahmatian (1992) present an analysis of the effects of hazardous waste sites on housing prices. Like Kohlhase, they use a hedonic price model with a number of physical housing characteristic variables in addition to a measure of distance to hazardous waste sites. They also include certain neighborhood variables, including school quality, operationalized by standardized math test scores, race, density and distance to work. The analysis is based on 2,323 sales in Baltimore from 1985 to 1986. In linear ($R^2 = .62$), semi-log ($R^2 = .74$) and log-linear ($R^2 = .77$) forms, the results show a significant and positive relationship between distance to nearest hazardous waste site and house price. Their analysis also found a significant and negative relationship between air quality and house price. This prompts the conclusion that homebuyers are willing to pay more for better environmental quality. This study, unlike some of the others reviewed here, does not focus on an event, such as a leak or announcement of an adverse environmental condition. Thus, before and after changes are not addressed.

Reichert, Small and Mohanty (1992) examined effects due to proximity to five municipal landfills in Cleveland. While the landfills were not deemed hazardous, perceptions of residents, addressed through surveys, identified concerns with health risks associated with proximity to the landfills. This was complemented by a sales

price analysis, which like the Kohlhase (1991) study, modeled price as a function of the physical characteristics of the properties, as well as distance to the disamenity. Unlike Kohlhase who aggregated data from all thirteen sites into a single model, Reichert, Small and Mohanty analyze and develop models for each of the five Cleveland sites separately. This disaggregation allows them to draw conclusions that differentiate impacts by the type of surrounding neighborhood. For example, in neighborhoods with expensive housing, price impacts are greater than in less expensive areas, older areas and in predominately rural areas. This suggests the presence of intervening market condition variables. Rural areas, older areas and areas with less expensive housing may have the weakest market conditions, and properties in these areas are found by Reichert, Small and Mohanty to have the least adverse price impacts due to proximity to the landfills.

In a more recent study, Reichert (1999) addresses the question of whether adverse environmental effects persist over time by building on a previous study (Reichert, 1997) of residential property impacts from a toxic waste Superfund site in Uniontown, Ohio. Using a concentric ring and hedonic modeling approach, Reichert estimated property value impacts within each of three rings during the ''initial'' impact period from 1988 to 1994 and an ''expanded'' impact period from 1988 to 1996. Reichert found little difference in the magnitude of impacts in the two periods, with ''damages'' ranging from 14.6% in the closest ring (initial and expanded periods) to 5.4% (initial period) and 5.8% (expanded period) in the ring furthest from the landfill. Further, since prices have generally appreciated over time, Reichert concludes that the value impacts have actually increased on a nominal price basis. However, Reichert notes that EPA's onsite remediation plan was not yet underway. Thus, this analysis does not directly address the question of whether impacts are lessened subsequent to remediation, since remediation has not been completed.

Another study of the same landfill analyzed by Reichert (1999), is presented by Wise and Pfeifenberger (1994), who arrive at contradictory conclusions.[3] They found that initially, and concurrent with intensive news coverage, property values declined by at much as 10% in the area around the landfill, but this decline lessened steadily over time. Further, they conclude that within four years, properties more than half a mile from the landfill had recovered, and within six years, properties within a half mile had recovered. These are much different findings than those reported by Reichert. The Wise and Pfeifenberger analysis shows a temporary impact, although neither Wise and Pfeifenberger nor Reichert test data subsequent to remediation, which had not yet been reported to have occurred.

A further study of negative environmental externalities on residential property values is offered by Kinnard, Mitchell, Beron and Webb (1991), who examine the effects of an announcement of a release of radioactive material on housing in a rural area. However, using a hedonic pricing framework with concentric rings, the authors conclude that the announcement had no statistically significant effect on prices that varied with location in the concentric rings closest to the source facility. In addition, price effects were tested over time, with continuous and dummy variables reflecting sales before and after the announcement. Again, no significant differences were

observed. These findings seemingly contradict the major conclusions of Kohlhase (1991) and Reichert (1997, 1999), except for Reichert, Small and Mohanty's (1992) finding that proximity effects were lower for landfills surrounded by predominant rural neighborhoods. In addition, Kohlhase's data was on urban housing in the Houston metropolitan area. Again, market condition may be a key intervening variable.

Other studies in this category are those of Kiel (1995) and Kiel and McClain (1996). In a study of groundwater contamination in Woburn, Massachusetts, Kiel found that information about contamination, including the EPA announcement of an Superfund site, had a statistically significant effect on housing prices. However, Kiel found that once the EPA had announced a cleanup of the site, the housing prices did not rebound. This somewhat contradicts Kohlhase and others who posit that prices recover following remediation. It is unclear whether these effects may be confounded due to market conditions and housing types. Kiel and McClain to some extent contradict the previous study by finding that for a proposed incinerator in New York state, house prices did rebound after the proposed siting was withdrawn. While this is not quite the same as a previously contaminated site that has been remediated or the promise by a federal agency to remediate a site, it is evidence to suggest that residual effects are reduced or eliminated subsequent to the removal of the adverse environmental condition.

Smolen, Moore and Conway (1992) present another study of landfill impacts on housing prices. Their study focused on an existing landfill in the Toledo, Ohio area and a proposed landfill in Sylvania, Michigan, near Toledo, from 1987 to 1990. The existing landfill was a depository for low level nuclear waste, and the proposed facility was to be of the same type. Smolen, Moore and Conway analyze price effects by distance from the existing landfill through a hedonic pricing model, with living space, number of half baths and distance to the landfill as the independent variables. They further divide the sales into three proximity rings and estimate separate equations for each ring. For the existing landfill, the results show a highly significant relationship between distance and price for houses located less than 2.6 miles from the facility. This effect lessens in the next ring, 2.6 to 5.75 miles and disappears from 5.75 miles out. The effect in the inner rings does not appear to change over time. For the proposed landfill, there was a significant distance effect following the announcement of the facility, which became insignificant once the proposal was rescinded. This is nearly the same finding as Kiel and McClain (1996). The finding that the price effects of the existing landfill do not diminish over time seems to be consistent with Reichert (1999).

Another view of the effects of adverse environmental conditions is offered by Clark, Michelbrink, Allison and Metz (1997). These researchers use hedonic modeling and geographic information system (GIS) techniques to analyze the effects of proximity to nuclear power plants over time. Their framework focuses on changes in the housing price function over time corresponding to changes in risk perceptions and changes in employment levels. Both of the plants they analyze are or have been significant employers in their regions, so that adverse proximity effects due to the hazardous

nature of the facility could be offset by the benefits of proximity to the workplace. For one of the two California facilities, Diablo Canyon, distance from the plant had a negative and significant effect on price (price decreased with distance), indicating that employment proximity outweighed any adverse environmental impacts. For the other plant, which was closed, the housing price function, plotted through the GIS, was U-shaped, with price premiums closest to the plant declining with distance and then rising at greater distances. The authors speculate that desirable lower densities or recreational amenities in some areas may be independently affecting the prices.

The question of changes in the impacts of contamination on residential property values before and after cleanup is directly addressed by Dale, Murdoch, Thayer and Waddell (1999). In this study, a lead smelter in the Dallas area had resulted in soil contamination that impacted surrounding housing. The researchers use hedonic pricing models of housing in the Dallas area before, during and after cleanup of the site in order to evaluate the extent to which prices may rebound subsequent to remediation and closure. In addition, they included data for housing sales after cleanup, but during a period when some new concerns had surfaced about the site. The RSR lead smelter facility had operated from 1934 to 1984. The cleanup was allegedly completed in 1985 to 1986. The post-cleanup period, referred to as the ''rebound period'' by the authors, when ''the health risks were believed to be under control'' was from 1987 to 1990. From 1991 to 1995, there was new publicity concerning the site's environmental risks and it was placed on the NPL list.

To analyze housing price effects during these periods, Dale, Murdoch, Thayer and Waddell (1999) develop separate housing price models for each time period, with distance from the site as an independent variable. Additional models include indicator variables for neighborhoods closest to the site. The results show that during the periods before cleanup, house prices further away from the site were significantly higher than prices closer to the site, but in the after cleanup period the prices for houses closest to the site had rebounded relative to other locations. Indeed, the distance variable coefficients in the results presented show that prices for houses closest to the site were slightly higher than other houses in the ''rebound'' period. This is also evident in the statistical results for the last period studied, when the site was placed on the Superfund list. This later finding contradicts Kohlhase (1991), who found that publicity over an NPL listing by the EPA had an adverse impact on housing prices. However, despite this discrepancy, the two studies appear to be consistent with respect to the temporary nature of the adverse price impacts of the environmental contamination.

The preceding sales price studies have addressed the impacts of hazardous and nonhazardous landfills, airborne radioactive releases, power lines, leaking and non-leaking nuclear power plants, incinerators and smelters. In addition, two studies evaluated the effects of groundwater contamination from an announced Superfund site. The sources for the contamination or environmental disamenity in these studies were substantial and generally well publicized. The next two studies deal with groundwater contamination from less than Superfund scale sources. The first, by

Simons, Bowen and Sementelli (1997), looked at leaking underground storage tanks. The second study by Dotzour (1997) analyzed impacts from groundwater contamination in Wichita, Kansas. The two studies arrived at opposite conclusions.

Simons, Bowen and Sementelli (1997) study the effect on residential sales prices due to proximity to underground storage tanks in Cleveland, Ohio. Their data includes 16,990 residential sales in 1992, some of which are located within 300 feet of 2,513 sites with underground storage tanks. The authors distinguish between: (1) non-leaking tanks that are registered with the State of Ohio; (2) leaking but unregistered tanks; and (3) currently leaking and registered tanks. A hedonic pricing model is used with Box-Cox transformations and in a linear format. In the linear specification, only the dichotomous independent variable for proximity to the leaking and registered tanks is statistically significant. With an average house price of $86,151, this proximity effect reduces the average price by $15,152, or by 17.5%. The model estimates have some other notable results. The coefficients for number of rooms and number of bedrooms are negative, which is probably due to collinearity with other independent variables. In addition, the most significant independent variable and predictor of sales price ($t = 29.07$) is a five-point ''quality'' ranking, which the authors do not explain, but may be a subjective rating of some kind.

The last study reviewed in this category is by Dotzour (1997), who analyzes residential properties in an area of downtown Wichita that had contaminated groundwater. All of the residences were connected to public water and sewer service. Dotzour compares the average sales price of houses in the contaminated area before and after the announcement of the contamination, and concludes that there was not a statistically significant difference, using a two-sample *t*-test procedure. Dotzour also analyzes changes in prices in two uncontaminated control areas and observes the same pattern of stability over the period before and after the groundwater contamination announcement. However, after the announcement of the contamination, Dotzour notes that lenders immediately ceased lending on any commercial properties in the contaminated area. As previously explained, since lenders provide a large proportion of the capital for commercial and industrial real estate development and acquisitions, the withdrawal of this source of capital could have significant effects on commercial real estate prices and values in the area.

The final study in the category of residential price impacts is by Simons (1999), who analyzes the effect of a petroleum pipeline rupture in Virginia. To evaluate the effect on prices of the 1993 rupture of the Colonial pipeline in Fairfax County on houses ''on pipeline'' but not directly contaminated, Simons developed hedonic price models of single-family house sales with indicator variables for pipeline properties and for sales occurring after the rupture. For sales on the pipeline and after the rupture, Simons finds a 5.5% reduction in price, which is significant at the 10% level ($t = -1.68$). The indicator variable for sales on the pipeline regardless of the year of sale was positive, indicating higher prices of 6.6%, and significant at the 5% level. However, the results of this model specification may not reflect actual impacts since there appears to be an omitted category, sales off the pipeline and after 1993. A more complete specification that ensures that no singularities have been introduced would

be to include indicators for sales on the pipeline, on the pipeline and after 1993, and off the pipeline and after 1993. Potential specification error in this regard is discussed by Rogers (2000).

Commercial and Industrial Properties

As noted, there have been few empirical studies dealing directly with contaminated commercial and industrial properties. Most are ''case studies'' rather than the hedonic price models that characterize the residential impact studies. Also, unlike the residential studies, the properties that are the subject of this research are usually the source sites themselves, and their value may be impacted by remediation costs, as well as the uncertainty and risk of investing and lending on these properties. The focus of the studies in this category is on these risk effects.

Page and Rabinowitz (1993) use a case study approach to evaluate the impacts of groundwater contamination. With six commercial and industrial cases from Pennsylvania, California and Wisconsin, and seven residential cases from Wisconsin, the authors found none of the presumed adverse impacts on residential property values, while the commercial and industrial properties had significant impacts from the contamination. They speculate that this is due to the levels of due diligence exercised by participants in the two markets as well as the assumption of responsibility for remediation and other liabilities involved in commercial and industrial property transactions. Although based on a limited amount of data, these findings underscore the differences between these property types, and highlight the need for additional research on the impacts of contamination on commercial and industrial real estate.

In a further application of the case study approach, Patchin (1994) reports on eight commercial and industrial transactions, finding a range of property value impacts from 20.9% to 93.7%. In addition, he notes that ''properties that are in demand generally experience less stigma (reduction in value) than those with many substitutes.'' Patchin's main point is that the increasing frequency of contaminated commercial and industrial properties transactions should allow for direct analysis of sales data, whereas in the past, transactions were too infrequent for reliable analysis and conclusions. Thus, for these property types, Patchin finds reductions in value, but also, and importantly, suggests that strong market conditions tend to mitigate the adverse effects of contamination. This is the opposite of the implications for market factors as mitigating factors suggested in the residential studies, where greater impacts were associated with stronger demand and vice versa.

The impacts of contamination on commercial property transaction rates and financing have been studied by Simons and Sementelli (1997) who compare commercial properties with leaking underground storage tanks (LUSTs) and properties with non-leaking tanks that have been registered with the State of Ohio (RUSTs) to other commercial properties (baseline). Data on sales of these properties is from Cleveland during the 1989 to 1992 period. With respect to transaction rates, the results show that both LUST sites and RUST sites transact at significantly lower rates than the baseline commercial properties, with the 10.4% of the baseline commercial properties

selling during the period, and transaction rates of 3.8% for LUST sites and 4.9% for RUST sites. However, it appears from this data that there is not a significant difference between RUST and LUST sites, implying a negligible effect due to the contaminated status of the LUST sites. With respect to mortgage financing, 32.6% of the baseline commercial properties that sold had mortgages, while 29.4% of the LUST property sales had mortgages and 9.3% of the RUST sales had mortgages. Thus, there was a significant difference between the baseline commercial property sales and the RUST sites, but there was not a significant difference between the contaminated LUST sales and the baseline sales in the frequency of mortgage financing. These results somewhat contradict the authors' stated conclusions that ''discovery of a LUST hinders the sale and financing of a property.'' Lastly, other results show that the average loan-to-value ratios (LTVR) for the non-tank baseline properties declined from 0.95 to 0.80 during the period, while the LTVR for the RUST sales averaged 0.51 and for the LUST sites was 0.84. Thus, the reported results show LUST sales with similar rates and levels of financing to other commercial properties. Again, this seems to contradict the authors' stated conclusions.

Another perspective on the Cleveland leaking underground storage tank sites is provided by Sementelli and Simons (1997), who analyze a sample of 429 sites over a four-year period. Among the findings of the study involved the effect of a ''no further action'' (NFA) letter from the State of Ohio. An NFA letter should signal the market that the site is remediated, and according to many of the previous studies, this should reduce investment and lending risk and improve marketability. However, when transaction rates were analyzed, Sementelli and Simons found that only 0.2% of the sites sold after receiving the NFA letters. This is much lower than the 10% transaction rate for non-tank commercial properties over the same period. Oddly, however, 4% of the sites that did not receive a NFA letter sold over the same period. Thus, it would seem that receiving a NFA letter from the state of Ohio increases risk and reduces marketability. This finding contradicts other studies reviewed herein, which found either a decrease in effect or a constant effect subsequent to remediation or removal of the environmental disamenity.

Simons, Bowen and Sementelli (1999) provide yet another look at leaking underground storage tanks in Cleveland. In this research, the effects of LUSTs on adjacent properties is examined. The authors state that their research on sales prices is complementary to direct surveys of market participants, noting that surveys can be more detailed and specific but are difficult to employ. The main hypothesis of the research is that contamination from nearby properties reduces the value of adjacent residential and commercial properties. Residential properties near LUST site are analyzed through a hedonic modeling process whereby the model sales price predictions, based on the sales of properties not near a LUST site, are compared to the sales prices of properties near a LUST site. The actual prices averaged 14.7% less than the predicted prices.

For commercial properties near LUST sites, three other approaches are used. In the first approach, the authors compared transaction rates of commercial properties near LUST sites with other commercial properties. They found that the properties adjacent

to the LUST sites transacted at a rate of 2.7% per year while other properties transacted at 4.0% per year, and using a difference of means test determined that this was statistically significant. The second approach compared the incidence of seller financing and determined that properties adjacent to LUST sites had a significantly higher rate of seller financing than other properties. The third approach is based on a paired sales analysis, comparing a sale before contamination was discovered and a resale after the contamination was known. Based on an analysis of six such sales, Simons, Bowen and Sementelli (1999) conclude that the average diminution in value due to the contamination was from 28% to 42%. The authors did not use a regression-based approach to analyze the commercial sales data.

There have been few attempts to model the price of commercial and industrial properties in a hedonic framework. As noted, hedonic modeling has been used extensively in analyzing residential properties and in estimating the effects of environmental contamination or hazards on housing prices. The application of this technique to commercial and industrial properties is limited by the difficulty of assembling a sufficiently large number of transactions on relatively homogenous properties. As noted by Epley (1997), the small size of samples of these sales can limit the reliability of statistical techniques such as multiple regression analysis because the underlying assumptions that the error terms be normally distributed with a zero mean and constant variance are usually not satisfied. However, Epley also notes that a ''small sample does not mean that a statistical model such as regression or minimum variance does not work,'' but that the analyst cannot test the reliability of the underlying assumptions. It should be noted that Epley's comments are directed at a typical sales comparison analysis with four or five sales.

One example of the application of hedonic techniques to commercial real estate is by Saderion, Smith and Smith (1994). Using data on apartment property sales in Houston from 1978 to 1988, the authors estimate the parameters for three models: (1) a ''standard hedonic'' with price as a function of property and market characteristics, including year of sale categorical variables; (2) an income model with income capitalization rates as a function of net operating income and the year of sale variables; and (3) a combined model with price as a function of property and market characteristics, year of sale and net operating income. The models are estimated in logarithmic form. The combined model produced the best fit with an R^2 of .926. The income model had the lowest explanatory power with an R^2 of .752, although the *t*-Statistic for net operating income of 27.97 indicates that it is a highly significant predictor. The authors seem to imply that the first model, with the property and market characteristics and year of sale, is similar to the sales comparison approach used by appraisers. The third model specification, with property and market characteristics as well as the income data, might represent some combination of the sales comparison and income capitalization approaches.

Saderion, Smith and Smith (1994) apply the hedonic modeling technique to uncontaminated commercial properties. An application of hedonic modeling to non-residential properties for purposes of estimating environmental impacts is by Guntermann (1995), who developed a hedonic pricing model for 183 industrial land

sales from 1984 to 1994, and the effect of proximity to landfills. Independent variables included a variety of size and locational characteristics as well as landfill proximity. The results of the study indicated that the value of industrial property around open landfills was reduced by proximity to the landfill, while the value of industrial properties around closed landfills was not reduced. This finding is consistent with the other studies that suggest that adverse impacts are temporary, and that these effects would dissipate subsequent to closure or remediation.

Summary of Sales Price Analysis Literature

There were several questions outlined at the beginning of this section. These included whether or not there was a measurable effect on price, the persistence or temporary nature of any effects, and the existence of any intervening factors. The results with respect to these questions are summarized in Exhibit 1. As can be seen, in the residential studies, published from 1982 to 1999, adverse price impacts from these and other sources were identified by fifteen studies and no price impacts, or positive price effects, were found in four studies. With respect to the temporary or permanent nature of the impacts, eight of the residential studies indicated that the effect was temporary and three indicated a permanent effect. The other residential studies did not address this issue. The few residential impact studies that addressed intervening variables did so briefly or indirectly. Nevertheless, potentially intervening variables that were noted included: the urban or rural nature of the market area in which the housing was located, with some indication of greater impacts in urban areas; the price of housing, as perhaps a proxy for market demand, with greater impacts in areas with higher priced housing and lesser impacts in lower cost areas; employment, with proximity to sources of employment mitigating potential impacts from environmental disamenities; and, in one study of groundwater contamination, the connection of housing to a public potable water supply. In summary, the studies of environmental impacts on these properties generally indicate that there is an effect on prices, but that this effect is temporary. In addition, urban areas and areas that have stronger market demand may be impacted to a greater degree than rural areas and areas with weaker demand. There is, however, a limited amount of evidence to date on these latter points.

In summarizing the studies on the effects of contamination on commercial and industrial properties, five of the seven studies dealt with impacts from groundwater contamination, including Dotzour (1997) who primarily analyzed residential properties. One study involved proximity to landfills, and another included various types of contamination. All of the studies on the effects of contamination on commercial and industrial sales prices and values found significant adverse impacts. The effects include reductions in sales price, reduced transaction rates and increased incidence of seller financing. The temporary or permanent nature of these effects was not addressed in most of the studies. One study found that a no further action letter from a regulatory authority, typically an indication of the completion of required remediation, did not increase the marketability of the properties. Another study found that the prices of properties near closed landfills were unaffected while prices of properties near active landfills in the same market were adversely impacted.

Exhibit 1
Summary of Sales Price Literature

Study	Property Type	Contamination Type/Source	Effect	Persistence	Intervening Factors
Gamble and Downing (1982)	Single-family residential	Three Mile Island, nuclear radiation	Price increases with distance from source, marketing time increases	Temporary effect, gone after four to eight weeks	None noted
Colwell (1990)	Single-family residential	Overhead power lines	Price increases with distance	Effect decreases over time	None noted
McClelland, Schulze and Hurd (1990)	Single-family residential	Non-toxic landfill	Price decreases in neighborhoods with high perceived health risks	Effects reduced after landfill closure	None noted
Kohlhase (1991)	Single-family residential	Superfund sites	Price increases with distance from sites	Effect reduced or eliminated after cleanup of sites, temporary effect	Urban area
Thayer, Albers and Rahmatian (1992)	Single-family residential	Hazardous waste site	Price increases with distance from site	Not addressed	None noted
Reichert, Small and Mohanty (1992)	Single-family residential	Non-hazardous municipal landfills	Adverse impact on prices	Not addressed	Price impacts were greater in areas with higher prices housing, less in areas with lower priced housing
Reichert (1997, 1999)	Single-family residential	Toxic waste landfill, Superfund site	Adverse impact closer to site	No change over time in magnitude of impacts	None noted
Wise and Pfeifenberger (1994)	Single-family residential	Toxic waste landfill, Superfund site (same site as Reichert, 1997, 1999)	Reduction in price for properties around landfill	Within 6 years all properties had rebounded	None noted
Kinnard, Mitchell, Beron and Webb (1991)	Single-family residential	Release of radioactive material	No effect on price	No effect	Rural area
Kiel (1995)	Single-family residential	Groundwater contamination	Adverse price effects	No recovery following announcement of cleanup	None noted

Exhibit 1 (continued)
Summary of Sales Price Literature

Study	Property Type	Contamination Type/Source	Effect	Persistence	Intervening Factors
Kiel and McClain (1996)	Single-family residential	Proposed incinerator	Adverse price effect after cleanup	Prices rebound following withdrawal of proposal	None noted
Smolen, Moore and Conway (1992)	Single-family residential	Existing and proposed low level nuclear waste depositories	Adverse price effects for proximity to both sites	Persistent effects for existing facility; effect for proposed facility insignificant after proposal was rescinded	None noted
Clark, Michelbrink, Allison and Metz (1997)	Single-family residential	Active and closed nuclear power plants	Proximity to plant had positive effect	Effects were stable over time	Proximity to plant provided employment (higher market demand)
Simons, Bowen and Sementelli (1997)	Single-family residential	Leaking underground storage tanks	House price reduced by 17.5% for leaking tank sites registered with the state	Not addressed	None noted
Dale, Murdoch, Thayer and Waddell (1999)	Single-family residential	Soil contamination from lead smelter	Prices for houses at increasing distances from source significantly higher before cleanup	Prices for housing closer to site experienced a "rebound" after cleanup	Model "controlled" for effects of different socioeconomic characteristics of neighborhoods closest to lead smelter site
Simons (1999)	Single-family residential	Petroleum surface spill from pipeline rupture	Prices for houses on pipeline and sold after spill reduced by 5.5%	Not addressed	None noted
Dotzour (1997)	Single-family residential and commercial	Groundwater contamination	House prices not effected; Commercial lending in contaminated area stopped (adverse effect)	Lack of effect on residential prices, prices were stable; Persistence of commercial lending effect not addressed	Contaminated area in downtown redevelopment area, residences on public water

Exhibit 1 (continued)
Summary of Sales Price Literature

Study	Property Type	Contamination Type/Source	Effect	Persistence	Intervening Factors
Page and Rabinowitz (1993)	Commercial, industrial and residential	Groundwater contamination	No impact on residential properties; significant adverse effects on commercial and industrial properties	Not addressed	None noted
Patchin (1994)	Commercial and industrial	Various	Negative price impacts ranging from 20.9% to 93.7%	Not addressed	Strong market conditions mitigate impact
Simons and Sementelli (1997)	Commercial	Leaking underground storage tanks, groundwater contamination	Financing effect and reduction in sales for non-leaking tank sites registered with state	Not addressed	Tank registration with state seems to have independent effect
Sementelli and Simons (1997)	Commercial	Leaking underground storage tanks, groundwater contamination	No further action (NFA) letter did not improve marketability	No positive effect due to NFA letter	None noted
Simons, Bowen and Sementelli (1999)	Single-family residential; adjacent properties (non-source) commercial and industrial properties	Leaking underground storage tanks, groundwater contamination	Residential prices reduced by 14.7%; Reduced transaction rates, increases in seller financing for commercial properties, prices reduced 28% to 42%	Not addressed	None noted
Guntermann (1995)	Industrial land	Open and closed landfills	Value of land around open landfills reduced, values around closed landfills not affected	Value impacts not found for closed landfills	Urban area

Three studies addressed both residential and commercial properties. Dotzour found that residential properties were unaffected while lending on commercial properties was adversely impacted by the discovery of groundwater contamination. Page and Rabinowitz (1993) reached a similar conclusion, with no impacts on residential properties and adverse effects on commercial and industrial properties due to groundwater contamination. Simons, Bowen and Sementelli (1999) found adverse impacts on both residential and commercial properties due to groundwater contamination. Intervening factors are not addressed by most of the studies, although Patchin (1994) indicates that strong market demand would mitigate the adverse effects of contamination on commercial and industrial properties. This is the opposite of what some of the other studies seem to say about market conditions and residential property impacts. There is a more apparent need for systematic study and additional research on all of these points with respect to commercial and industrial properties.

Endnotes

1. Chalmers and Roehr (1993) and Mundy (1992a,b,c) use different risk adjusted discount rates over their holding period. Mundy varies his risk premium for past period and future periods. Chalmers and Roehr vary their risk premium so that it declines as remediation is completed. Chalmers and Roehr discount each period's cash flow back only one period at the risk-adjusted rate for that period and then discount the result back for the previous period at that period's rate and so on until a present value is reached. Mundy discounts each period's cash flow back to present value at that period's discount rate.
2. Use restrictions could involve a legal limitation on the current or future use of the property due to the contamination and its remediation. For example, an industrial property remediated to industrial clean-up standards may have a restriction on its future use for industrial purposes. The property could not be used for residential or other uses without additional remediation. The use restriction is typically carried as a deed restriction.
3. It should be noted that Wise was an expert for the defendants in the case involving this landfill, *DeSario v. Industrial Excess Landfill* in the Ohio Court of Common Pleas while Reichert was an expert on the plaintiff's side.

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