NCEE
NATIONAL CENTER FOR
ENVIRONMENTAL ECONOMICS

A Hedonic Analysis of the Impact of LUST Sites on House Prices in Frederick, Baltimore, and Baltimore City Counties

Jeffrey Zabel and Dennis Guignet

Working Paper Series

Working Paper # 10-01
January, 2010

U.S. Environmental Protection Agency
National Center for Environmental Economics
1200 Pennsylvania Avenue, NW (MC 1809)
Washington, DC 20460
http://www.epa.gov/economics

A Hedonic Analysis of the Impact of LUST Sites on House Prices in Frederick, Baltimore, and Baltimore City Counties

Jeffrey Zabel and Dennis Guignet

NCEE Working Paper Series
Working Paper # 10-01
January, 2010

A Hedonic Analysis of the Impact of LUST Sites on House Prices in Frederick, Baltimore, and Baltimore City Counties

Jeffrey Zabel
Economics Department
Tufts University

and

Dennis Guignet
Department of Agricultural and Resource Economics
University of Maryland

KEY WORDS: LUST, Hedonic Analysis, Groundwater Contamination, Remediation Benefits

Abstract

Petroleum from leaking underground storage tanks (LUSTs) can contaminate local soil, and surface and groundwater. In some cases this can pose health risks to the surrounding population. Focusing on single family home sales from 1996-2007 in three Maryland counties, we use a hedonic house price model to estimate the willingness to pay to live father away from LUST sites. Particular attention is given to how property values are affected by leak and cleanup activity at a LUST site, the severity of contamination, the presence of a primary exposure path (i.e., private groundwater wells), and publicity surrounding a LUST site. The results suggest that although the typical LUST site may not significantly affect nearby property values, more publicized (and more contaminated sites) can impact surrounding home values by more than 10%.

We would like to thank the National Center for Smart Growth at the University of Maryland for providing us with the housing transaction data. We also would like to thank Anna Alberini, Chip Paterson, and particularly Kelly Maguire for useful comments.

1. INTRODUCTION

Petroleum products are used in many industrial activities, and some products (such as motor fuel) are sold to consumers at commercial facilities. Such facilities are widespread, and often store petroleum products onsite in underground storage tanks (USTs). For example, USTs are commonly used at gas stations to store gasoline, diesel, and other petroleum products.

Over time leaks may occur as a result of corrosion and rusting, cracks, defective piping, and because of spills during refilling and maintenance activities. Petroleum from leaking underground storage tanks (LUSTs) contaminates the surrounding soil and can percolate into local groundwater aquifers. Oil contamination can migrate via surface run-off or local groundwater flows, and could potentially contaminate the surrounding environment and nearby water bodies. As of March 2009, there were over 482,166 known UST releases throughout the United States.[1]

In addition to environmental contamination, LUSTs can pose potential adverse health risks. Vapors can travel upwards into nearby homes and other structures. This poses several acute health risks such as headaches, nausea, and even potential explosions.[2] Exposure to petroleum products over long periods of time increases the risk of some chronic diseases. Consumption of contaminated groundwater is the primary exposure path of concern. Petroleum products break down to several carcinogens and other contaminants that can affect the kidneys, liver, and nervous system. As a result,

[1] US Environmental Protection Agency (EPA) http://www.epa.gov/oust/faqs/faq9a.htm, Accessed July 16, 2009.

[2] Maryland Department of Environment (MDE), http://www.mde.state.md.us/assets/document/LRP%20Vapor%20Intrusion%20Guidance(6).pdf, accessed July 16, 2009.

concentration levels of these petroleum constituents in drinking water are regulated by the US Environmental Protection Agency (EPA).[3]

Due to the potential environmental costs and health risks, LUSTs may adversely affect the welfare of nearby residents. If so, the cleanup of contamination from a LUST should result in some benefit to residents. We attempt to measure the benefits of cleaning up LUSTs, as reflected in residential property values. A hedonic property value model is estimated using single family home sales from 1996-2007 in three Maryland counties: Baltimore City, Baltimore, and Frederick. Careful attention is given to how property values are affected by leak and cleanup activity at LUST sites, the severity of contamination, the presence of a primary exposure path (i.e., private groundwater wells), and publicity surrounding a LUST site. The main conclusion from this analysis is that the average LUST site is unlikely to have a significant impact on house prices. However, the results suggest that the most publicized (and more contaminated sites) LUST sites can significantly impact nearby property values by more than 10%.

This paper proceeds as follows. In Section 2, we provide a literature review. In Section 3, we discuss the data that we will use to estimate the hedonic model. This includes the property transaction data we were able to obtain from the National Center for Smart Growth and the LUST data that we obtained from the Maryland Department of the Environment. In Section 4, we lay out the framework for using the hedonic model. We pay particular attention to measuring the baseline impact of living near the UST site prior to discovery of the leak so that the impact of the LUST site is measured with respect to this baseline. In Section 5, we present the results, followed by some concluding remarks in Section 6.

---

[3] US EPA, http://www.epa.gov/safewater/contaminants/index.html#listmcl, accessed July 16, 2009.

2. LITERATURE REVIEW

There is a large literature that provides evidence that hazardous waste sites adversely affect the prices of nearby residences. Boyle and Kiel (2001) provide a recent survey of the literature. A significant portion of the hedonic residential property value studies focus on Superfund sites. Comparing across these studies Farber (1998) finds that surrounding residential property values increase, on average, by $3,500 for each additional mile away from a hazardous site. Boyle and Kiel (2001) find significant variation in this premium across studies ranging from $190 to $11,450.

The relatively small literature on the impact of contamination on the value of non-residential properties is surveyed in Jackson (2001). This includes the impact on the values of nearby commercial and industrial properties and on the contaminated property itself. Jackson analyzes seven studies (Dotzour (1997), Guntermann (1995), Page and Rabinowitz (1993), Patchin (1994), Sementelli and Simons (1997), Simons and Sementelli (1997), and Simons, Bowen and Sementelli (1999). Jackson reports that all of these studies that estimate the impact of contamination on the sales prices of commercial and industrial properties find significantly negative effects.

Some studies focus on the value of the contaminated property itself. McGrath (2000) estimates a hedonic equation of sales prices of industrial properties in Chicago that includes the probability of contamination, PROBCON. The estimated coefficient for PROBCON is negative and significant. The impact is a 76% median unit discount or approximately a one million dollar ($1995) per acre decrease in parcel value. This is a particularly large impact and McGrath speculates that “investors are perhaps either overestimating the financial liability or that the discounts incorporate the present value of required legal costs certain to be part of any site redevelopment." (page 440). Jackson (2002) estimates the impact of current or previous contamination on prices using a hedonic equation applied to sales of industrial properties in Southern California. He finds that contaminated industrial properties sell for a discount of approximately thirty percent, on average. Alberini (2007) examines the "contamination discount" of selected contaminated properties in Colorado and finds that the contaminated property appreciates in value after participation in the Colorado Voluntary Cleanup Program.

In the remainder of this literature review, we first focus on studies relevant to our analysis of the impact of LUST sites/groundwater contamination on property values. Initially we consider impacts on nearby properties. We then review the literature on the impacts on the LUST sites, themselves. Second, we consider the impact of property contamination on the likelihood that such properties will be redeveloped. Third, we look at three studies that use data from our study area, Maryland.

2.1 The Impact of LUST Sites/Groundwater Contamination on Property Values; Nearby Sites

One study that looked specifically at LUST sites is Simons, Bowen and Sementelli (1997; henceforth SBS97). SBS97 analyze the impact of USTs on 16,990 residential sales in Cuyahoga County, Ohio in 1992 (this includes the city of Cleveland). They considered three types of USTs: non-leaking tanks registered with the State of Ohio, and registered and unregistered LUSTs. There were 2,513 tank sites; 1,151 non-leaking, 835 leaking but unregistered, and 527 leaking and registered. SBS97 cite a study by Bowen, Salling, Haynes, and Cyran (1995) that developed a ranking of the toxicity of noxious environmental releases. Based on their analysis, LUSTs are expected to have a very localized impact. SBS97 interpreted this to mean being within sight distance or within a city block (300 feet). Hence, they generated indicator variables for units within this distance of the three types of USTs. There were 83 sales within the required distance of an UST; 42 near non-leaking USTs, 24 near leaking but unregistered USTs, and 17 near leaking and registered USTs. The only indicator that was marginally significant (at 5% but not at 1%) was for leaking and registered USTs. The estimated coefficient indicated that houses near a registered UST that is known to have leaked sold for a discount of $15,152 or 17% of the average sales price in 1992. This result should be viewed with caution since it is based on a small number of sales (17) and the model does not control for other potential LULUs (locally undesirable land uses) that could bias the result.

Page and Rabinowitz (1993) analyze the impact of groundwater contamination on residential and non-residential properties. They note that the nature of groundwater flows complicates the analysis; “Neither the direction nor the rate of movement of plumes of toxic chemicals in ground water is predictable without a thorough and costly hydrogeological investigation.” (page 473) The analysis of non-residential properties is based on a few case studies of abandoned industrial properties. The authors find that groundwater contamination significantly negatively affected the value of these properties (though it is not clear how they did this). The residential analysis considers properties in seven rural towns or small cities in Wisconsin that depend on private groundwater wells. The authors compare units with groundwater contaminated with toxic chemicals to similar nearby properties with wells with no identified contamination. They find no difference in the prices across these two groups of properties.

Dotzour (1997) looks at the impact on sales prices of residential properties in an area of Wichita Kansas where groundwater contamination had been discovered. However, few of the properties in the contaminated area used the groundwater as drinking water. Dotzour compared the change in average sales price of units in the contaminated area during the year before and after the contamination announcement to comparable changes in two control areas. The results showed no significant differences across the three study areas.

2.2 The Impact of LUST/Groundwater Contamination on the Property Values and Transaction Rates of LUST Sites

Simons, Bowen and Sementelli (1999; henceforth SBS99), Simons and Sementelli (1997) and Sementelli and Simons (1997) compare property values and transaction rates of LUST sites versus non-LUST sites. All three studies use data from the same location and hence cannot be considered to provide independent information. SBS99 analyze residential and commercial properties in Cuyahoga County, Ohio. Using the residential properties, SBS conducted a limited hedonic analysis. They found that residential properties near and/or with actual contamination from a LUST sold for a 14-16% discount (consistent with SBS97). They also estimated that commercial LUST sites sold at an annual rate of 2.7% whereas the annual transaction rate for uncontaminated sites was 4.0%. Hence, the transaction rate for the LUST sites was 33% lower than for those sites without contamination. These results are suggestive at best since they are based on a very small sample of contaminated properties. In the case of the commercial analysis, it is likely that the difference in transaction rates between contaminated and uncontaminated properties is not statistically different from zero. Further, this analysis does not control for the characteristics of the sites, so it is unclear if this difference is solely driven by differences in contamination levels. Using a similar dataset, Sementelli and Simons (1997) find that a No Further Action (NFA) letter has no impact on the transaction rates of LUST sites.

Simons and Sementelli (1997) compare the transaction rates of LUST and registered nonleaking tank (RUST) commercial sites. They note that in Cuyahoga County, most of the drinking water comes from Lake Erie and is provided by the City of Cleveland Water Department. Hence, 98% of the LUST sites use municipal drinking water and hence the health risks are minimal. But it is expected that LUST sites will be slower to sell. Results show that the transaction rates for LUST sites over a four year period was 3.8% versus 10.4% for comparable, uncontaminated (non-RUST or LUST) sites. Further, the transaction rate for RUST sites was only 4.9%. Relative to sites with no USTs present, buyers may be reluctant to purchase properties with RUSTs in fear of future liability, and remediation and removal costs. RUST and LUST sites were also found to be less likely to obtain secured mortgage financing and loan-to-value ratios were lower than for other commercial properties.

2.3 The Impact of Contamination on Redevelopment

Many observers suggest that contamination—whether actual or merely suspected—is likely to impair the redevelopment of properties. Three studies focus on the impact of contamination on the redevelopment of such properties. Sigman (2005) estimates the impact of CERCLA liability laws on the redevelopment rates of industrial sites in the U.S. The data are annual city-level observations from 1990 to 2000. The data are from surveys of realtors and are not transaction data. The dependent variable is the vacancy rate of industrial space. Sigman uses fixed effects to capture unobserved city-specific factors that can affect vacancy rates. The presence of CERCLA joint and several liability laws implies a 40% increase in vacancy rates in city centers. There is suggestive evidence that joint and several liability has a bigger impact in cities with a higher risk of contamination. Strict liability does not significantly affect vacancy rates. The impact of joint and several liability on vacancy rates in suburban areas is negative but not significant. Sigman also finds similar results using a data set of brownfield sites; the presence of joint and several liability in a city is associated with 67% more brownfield sites. These results are not as strong as the previous ones since the data are cross-sectional and hence it is not possible to use fixed effects to capture unobserved city-level factors that are correlated with liability laws. Also, the definition of a brownfield is not standardized across cities.

McGrath (2000) also analyzes the impact of contamination on the likelihood of redevelopment for 195 industrial properties in Chicago that sold between August 1983 and November 1993; 95 of which were redeveloped. Individual property contamination levels are not known, so McGrath uses a list of contamination probabilities for 25 industrial and commercial land-uses to generate the probability of contamination variable, PROBCON. McGrath estimates a probit model where the dependent variable is whether or not a property that sold is redeveloped. The estimated coefficient for

PROBCON is negative but not significant. Hence, there is no evidence that redevelopment of a purchased site is affected by the probability that a site is contaminated.

Lange and MacNeil (2004) estimate a logit model where the dependent variable is whether or not the redevelopment of a brownfield site was “successful” or “not-so-successful” (the authors do not state was it means for redevelopment to be successful). The data on 26 successful and 26 not-so-successful sites were obtained from surveys sent to 228 representatives of EPA brownfield assessment pilots (the response rate was 24%). Four factors were found to significantly affect successful redevelopment: an index of political support (financial incentives and limitations on developer liability) and the willingness of the lending institution to cooperate on project financing, adequacy of infrastructure, the fraction of the site redeveloped as office or commercial use, and the fraction devoted to greenspace (the latter two are relative to the fraction redeveloped for residential use).

2.4 Three Studies using Data from Maryland

Thayer, Albers and Rahmatian (1992) estimate the impacts of hazardous and non-hazardous waste sites on house prices in Baltimore from 1985 -1986. Results show a strong positive relationship between distance to hazardous waste site and price; prices increase by approximately 2% per mile further from the site. This positive relationship seems to level off with increased distance, but remains for at least four miles away from the site. They also found a significant positive relationship between air quality and price; a 6% increase in air quality led to an approximate 4% increase in price.

Howland (2000) focuses on parcels in an industrial area of Baltimore, finding that contamination reduces the sale price, but does not slow down transactions. Schoenbaum (2002) examines values, and vacancy and turnover rates for another industrial area in Baltimore, and reports no evidence of significant differences across brownfields and non-brownfield properties.

In summary, there have been numerous studies on the effects of hazardous waste sites on surrounding residential property values. In contrast, based on the literature review above, there are few studies of the effects on residential property values from groundwater contamination and specifically from LUSTs. Research on LUSTs and surrounding residential property values have been confined to just one geographic area (Cuyahoga, Ohio), and are limited in reliability due to few sales in close proximity of a LUST site. Further, the analysis of the impact of environmental contamination on non-residential properties is relatively small and not well developed from a statistical standpoint.

3. DATA

The hedonic analyses will focus on three counties in Maryland: Baltimore City, Baltimore County, and Frederick. First we give a description of the UST sites in these three counties and then provide details of the housing data.

3.1 UST Sites Description

Data on the 640 “Remediation Cases” in the study area were obtained from the Maryland Department of Environment’s (MDE) Oil Control Program. We focus on the 387 cases where a leak was discovered between 1996 and 2007. This corresponds to the period of available home sales data. Out of the 387 cases, 180 were in Baltimore County, 123 in Baltimore City County, and 84 in Frederick County. We exclude cases with invalid coordinates, cases that are simply a residential location with a contaminated groundwater investigation and not linked to a specific LUST, when the 'leaking' event was minimal and resulted in nothing that could conceivably affect house prices, and if contamination was the result of something other than a leaking tank. This leaves 219 cases: 110 in Baltimore County, 66 in Baltimore City County, and 43 in Frederick County. Figures 1 and 2 display the LUST sites in the three counties.

Table 1 shows the breakdown of case openings and closings by year. A case is open when an investigation regarding a potential leak is warranted, which may occur for several reasons, including: odor or water taste complaints from nearby residents, issues regarding routine onsite groundwater testing or UST system compliance checks, discrepancies in product inventory records, and if an UST owner reports an issue. Once a case is opened MDE investigates the situation and determines the best course of action, which may or may not include active cleanup. Petroleum products naturally degrade over time, so if there is no public or environmental threat, then ongoing monitoring and natural attenuation is sometimes deemed the best course of action (US EPA, 2004; Khan et al., 2004).

A case is closed when MDE is satisfied that there is no contamination, or there may be contamination but no exposure, or, if undertaken, cleanup is well underway or complete. Overall a case is closed once the LUST is no longer considered an environmental or health threat. Of these 219 sites, 149 were closed by 2008. A few sites were open and closed on the same day. It is likely that this may happen when the results of a relatively small investigation that turned up little to worry about are entered (date open) at the same time when MDE enters their conclusion (little to worry about; date closed). Some of these cases are merely investigations in response to a complaint MDE receives. When the inspector gets to the site they may find nothing and just close the case right away. This seems to happen often with vapor investigations. Also, surface spill cases are sometimes minor and cleaned up right away with kitty litter, so these cases are usually closed right away also.[4]

Considering the 149 cases that were closed by 2008, the average leak case was open for 1.53 years, the median is 0.57 years, and the maximum is just under 10.5 years. Regarding the leak cases that remained open as of 2008, the average case is open for 3.10 years (the median duration is 4.68 years).

There is information on relative risk categories (1-4; 1 is riskiest) but these do not appear to provide relevant information about the health risks associated with each LUST site. Instead, we use information on groundwater testing for petroleum concentration. We use these data because groundwater is the primary exposure path of concern and testing is done much more often than vapor and soil testing. We focus on concentration values for BTEX; the summation of benzene, toluene, ethylbenzene, and xylene. This

[4] We have information on cleanup dates but they are reported only semi-annually. Therefore, we do not use this information in this analysis.

aggregate measure of pollution is commonly reported, though only the individual components (benzene, toluene, ethylbenzene, and xylene) are regulated. The variable we use is btex_max; the maximum of the btex summation at any single time and testing location, including both on and offsite testing associated with a case. Testing is only carried out at 148 of the 219 LUST sites so we include a testing indicator in the hedonic model.[5] The mean and median values for btex_max are 17,818.82 and 280.75, respectively so the distribution is severely skewed right (concentrations are in micrograms/liter, which is equivalent to ppb). There are 24 LUSTS where the btex_max concentration is zero.

3.2 Sales Data

The data come from the MDProperty View CAMA (Computer Assisted Mass Appraisal) Database. This database is created on a yearly basis using data obtained from the State Department of Assessments and Taxation (SDAT). We have data from the 1996 – 2007 editions of this database. Each year provides information on the most recent sale for each unit in Frederick County, Baltimore County, and Baltimore City County so our dataset includes all sales between 1996 and 2007.

Although much of the stock of housing in Baltimore consists of townhomes (attached and semi-attached homes) and condominium apartments, we will restrict attention to single-family homes. We do so for the sake of comparability with Baltimore

[5] There does not appear to be an explicit testing criterion. Still, testing is more common at sites where there is a potential exposure path (groundwater being used) and if individual homes are nearby that could potentially be exposed. Further, the severity of the LUST event is also a factor in determining whether testing takes place.

and Frederick Counties, where single family homes are prevalent, and with previous hedonic studies, which have largely focused on single-family homes.

For each home, we have the exact address, latitude and longitude, and the names and the address of the owner. The latter information can be used to determine whether a home is owner-occupied. We also have the size of the lot, the square footage of the home, the age of the home, the quality of the structure (fair, average, good, very good), the type of heating and whether air conditioning is present, the number of bedrooms, the number of baths, the number and type of fireplaces, the presence, type and size of a porch, the presence and size of a garage, and the type of construction (e.g., brick, stucco). We have a general description of the dwelling (e.g., "1 story with basement") but we do not know the style of the home (e.g., Cape Cod, Federal style, etc.).

Because we have the coordinates of most homes, we also know which census tract and block group these homes fall in. There are sufficient sales to allow us to include block group fixed effects in Baltimore and Frederick Counties and census tract fixed effects in Baltimore City County. These fixed effects allow us to control for all local amenities and disamenities that are common to all units in the block group (or census tract) and are constant over the time period of our analysis; 1996-2007. We believe that local public goods such as school quality and safety are constant over this time period so we do not have to include these variables in our model. We also do not include accessibility (in terms of distances) to the city center, downtown Washington DC and downtown Baltimore (employment centers), and tunnels (Harbor and Fort McHenry Tunnels) since these are essentially constant within block groups and census tracts. We do include distances to local amenities such as lakes, open spaces, commercial districts, and major roads. We also have calculated the number of UST facilities (leaking or not) within a 500 meter radius of each housing unit. We also know whether each house is within the public water service area, or outside this area and presumably reliant on private groundwater wells. For Baltimore City County, this is not an issue because all homes are served by city water.

Units were excluded if lot size is greater than 10 acres (or recorded as zero), if the house was built prior to 1800, or was larger than 8,000 (enclosed) square feet. Units were also excluded if there were zero full baths or more than ten full baths and if ten half baths were recorded. Sales that were not arms length and prices that were less than twenty thousand dollars or more than five million dollars were dropped. Finally, we exclude cases with missing geographic coordinates. The final dataset includes 35,552 sales from Frederick County, 76,968 sales from Baltimore County, and 24,296 sales from Baltimore City County. Summary statistics for these three jurisdictions are given in Table 2.

4. MODEL DEVELOPMENT

We now develop the framework for using the hedonic method (as applied to property values) to calculate the benefits from the cleanup of a nearby LUST site. For this analysis, we focus on measuring the benefits that accrue to residential units, though this can easily be generalized to include commercial and industrial sites. Assume that the price for house i in block group g at time t (P_{igt}) is a log-linear function of house characteristics (H_{it}), neighborhood characteristics (N_{igt}), and a LUST site (LUST). Given the prevalence of LUST sites, we allow for the possibility that price can be affected by multiple sites. The impact of LUST is specified as a general function of the distance to the site in meters (D_i) and the health risks associated with the LUST site (R_t). Initially, assume that the region of analysis consists of a single housing market. Then the hedonic model can be expressed as

$$\ln P_{igt} = \beta_{0t} + \beta_1 H_{it} + \beta_2 N_{igt} + \sum_{j=1}^{J} LUST\left(D_{ij}, R_{jt}\left(D_{ij}\right); \theta_{jt}\right) + v_g + u_{it} \qquad (1)$$

where J is the number of LUST sites that affect the price of unit i and v_g is a block group fixed effect. The coefficients to be estimated are β_{0t}, β_1, β_2, and θ_{jt}. We include block group fixed effects to capture unobserved neighborhood quality at the block group level. This is important if we hope to interpret the impact of LUST on house prices as a causal impact. V_g will minimize omitted variables bias that can arise if the unobserved neighborhood characteristics are correlated with LUST. This is likely since LUSTs are not randomly assigned. Note that any neighborhood characteristics that are included in N_{igt} that are constant within the block group will be absorbed in v_g; only neighborhood characteristics that vary within the block group such as distances to particular local amenities and disamenities are included in N_{igt}.

Rosen (1974) showed that the coefficients in equation (1) can be interpreted as the implicit prices for the characteristics of the heterogeneous good that is being modeled. In equilibrium, these prices are equal to the marginal willingness to pay (MWTP) for each characteristic. Since the unit of observation is the house, P_{it} is the present discounted value (at time t) of the stream of rents from house i. Thus, θ_t will measure the present discounted value at time t of the present and future impact of the LUST site. This can be interpreted as the benefits (as measured by MWTP) from living farther away from the site. In certain circumstances, θ_t can be used to measure the MWTP to clean up a LUST site once knowledge of the extent of leakage is available. The coefficients, θ_t, are allowed to vary to account for changes in the MWTP for the LUST site over time. For example, θ_t may be zero if the UST has yet to be discovered as a LUST site. θ_t may also be positive or negative at this time if the net benefits from living near the site are positive or negative (the convenience of living near a gas station could be viewed as a positive benefit whereas the traffic concerns and the aesthetics of living near a gas station could generate negative benefits). θ_t may also depend on whether site testing has occurred, whether the site is in the process of being cleaned up or redeveloped or whether cleanup and/or redevelopment has been completed and the extent to which this information is public knowledge.

We expect the impact to vary based on whether the sale occurred prior to discovery (i.e., before the open date), while the leak case was open or after it was closed. We considered several different specifications for the spatial impact of a LUST on house prices; using (a function of) distance to the site and different distance buffers such that the impact is constant within the buffer. We found that the latter worked better given the local nature of the impact, the likely nonlinearities associated with distance and the limited number of observations that were close to LUST sites during the three impact periods. To capture the impact of the LUST sites on house prices, a series of variables are created based on the 100, 200, and 500 meter buffers. We choose the 100 meter buffer since we expect the impact to be very local and 100 yards has been used in previous literature (Simons, Bowen and Sementelli 1997).

First, the variable PRE_100 is the number of LUST sites within 100 meters of a unit with a sales date that was prior to the open date for each qualifying LUST site. Second, the variable OPEN_100 is the number of LUST sites within 100 meters of a unit with a sales date on or after the open date but prior to the closed date for each qualifying LUST site. Finally, the variable CLOSED_100 is the number of LUST sites within 100 meters of a unit with a sales date that was after the closed date for each qualifying LUST site. The impact of PRE_100 will measure the capitalized value of an additional LUST site within 100 meters of the unit prior to the open date. This impact could be positive, zero, or negative depending on the average value residents placed on living near an additional UST site. If the opening of a LUST site has a negative impact on the willingness to pay (WTP) to live near the site, then the coefficient for OPEN_100 should be less than the coefficient for PRE_100. The difference in these coefficients is the impact of the opening of the LUST site on WTP. Finally, if the closing of a site indicates that the risk from the site has decreased, we expect that the coefficient for CLOSED_100 will be greater than that for OPEN_100. Note that the coefficient for CLOSED_100 need not be the same as PRE_100 if there is lingering stigma attached to the UST site or if the use of the site is not the same as prior to its opening date (for example, the gas station does not re-open).

We define PRE_200, OPEN_200, and CLOSED_200 to be measures of the number of LUST sites within 200 meters of a unit with a sale date that is prior to the opening of each qualifying LUST site, during the period each qualifying LUST site is opened, and after the closure of each qualifying LUST site. We define PRE_100_200, OPEN_100_200, and CLOSED_100_200 to be measures of the number of LUST sites between 100 and 200 meters of a unit with a sale date that is prior to the opening of each qualifying LUST site, during the period each qualifying LUST site is opened, and after the closure of each qualifying LUST site. We define PRE_500, OPEN_500, and CLOSED_500 to be comparable measures of LUST sites within 500 meters of a housing unit. Finally, we define PRE_200_500, OPEN_200_500, and CLOSED_200_500 to be comparable measures of LUST sites between 200 and 500 meters of a housing unit.

Model 1 is specified as

$$\begin{aligned} \ln P_{igt} &= \beta_{0t} + \beta_1 H_{it} + \beta_2 N_{igt} + \beta_{31} PRE\_k_{igt} + \beta_{32} OPEN\_k_{igt} \\ &+ \beta_{33} CLOSED\_k_{igt} + v_g + u_{igt},\ k = 100, 100\_200, 200\_500 \end{aligned} \tag{2}$$

where

PRE_k_{igt} = The number of LUST sites in the k00 buffer of unit i where sales date t was prior the to opening date for each qualifying LUST site.

$OPEN\_k_{igt}$ = The number of LUST sites in the k00 buffer of unit i where sales date t was on or after opening date and before the closing date for each qualifying LUST site.

$CLOSED\_k_{igt}$ = The number of LUST sites in the k00 buffer of unit i where sales date t was on or after the closing date for each qualifying LUST site.

Note that the open and closed dates are not necessarily public knowledge. However, the opening date often corresponds to the release time and the closed date corresponds to the site being cleaned up, or at least deemed by the regulator as no longer a threat, which may be public knowledge. Further, we have not used the information of cleanup dates because they are often inaccurate.

Thus far, we assume that the health risk of each LUST site only depends on the distance to the site. We will now allow for health risk to be associated with groundwater testing for petroleum concentration. The variable we use is btex_max. We still allow for separate impacts prior to discovery, once the site is open and after it is closed. First, since all sites are not tested and the subset that is tested is unlikely to be random, we include three variables that measure the number of LUST sites within the k-meter buffer of a unit with a sale date that is prior to the opening of each qualifying LUST site, during the period each qualifying LUST site is opened, and after the closure of each qualifying LUST site. For the 100-yard buffer these indicators are: PRE_TESTED_100, OPEN_TESTED_100, and CLOSED_TESTED_100. Next, we interact these same three variables with the btex-max concentration to allow the impact to vary with the concentration level. We can now specify Model 2 as

$$\begin{aligned} \ln P_{igjt} &= \beta_{0t} + \beta_1 H_{it} + \beta_2 N_{igt} + \beta_{31} PRE\_k_{igjt} + \beta_{32} OPEN\_k_{igjt} + \beta_{33} CLOSED\_k_{igjt} \\ &+ \beta_{41} PRE\_TESTED\_k_{igjt} + \beta_{42} OPEN\_TESTED\_k_{igjt} + \beta_{43} CLOSED\_TESTED\_k_{igjt} \\ &+ \beta_{51} PRE\_BTEX\_MAX\_k_{igjt} + \beta_{52} OPEN\_BTEX\_MAX\_k_{igjt} \\ &+ \beta_{53} CLOSED\_BTEX\_MAX\_k_{igjt} + v_g + u_{igjt}, \qquad k = 100, 100\_200, 200\_500 \end{aligned} \tag{3}$$

where

$PRE\_TESTED\_k_{igt}$	=	The number of LUST sites in the k00 buffer of unit i that were tested where sales date t was prior to the opening date for each qualifying LUST site
$OPEN\_TESTED\_k_{igt}$	=	The number of LUST sites in the k00 buffer of unit i that were tested where sales date t was on or after the opening date and prior to the closing date for each qualifying LUST site

$CLOSED\_TESTED\_k_{igt}$	=	The number of LUST sites in the k00 buffer of unit i that were tested where sales date t was on or after the closing date for each qualifying LUST site
$PRE\_BTEX\_MAX\_k_{igt}$	=	The maximum btex_max concentration for qualifying LUST sites in the k00 buffer of unit i where qualifying LUST sites were tested and had opening dates that were after the sales date t, and 0 otherwise
$OPEN\_BTEX\_MAX\_k_{igt}$	=	The maximum btex_max concentration for qualifying LUST sites in the k00 buffer of unit i where qualifying LUST sites were tested and had opening dates that were on or before the sales date t and closing dates that were after sales date t, and 0 otherwise
$CLOSED\_BTEX\_MAX\_k_{igt}$	=	The maximum btex_max concentration for qualifying LUST sites in the k00 buffer of unit i where qualifying LUST sites were tested and had closing dates that were on or before the sales date t, and 0 otherwise

Another important indicator of the impact of the LUST sites on house values is whether or not households receive their water from public sources. Units that receive their water from local private sources will be subject to higher potential health risks from LUST sites due to groundwater contamination. Units that receive their water from public sources will be not subject to the health risks from local groundwater contamination since their water comes from non-local sources. Also, public water systems are regulated by the Safe Drinking Water Act, whereas private wells are not. Thus we allow the impacts in the three periods to vary by whether water is obtained from a public or private source. Model 3 is specified as

$$\ln P_{igt} = \beta_{0t} + \beta_1 H_{it} + \beta_2 N_{igt} + \beta_{31}^{p,np} PRE\_k00_{igt}^{p,np} + \beta_{32}^{p,np} OPEN\_k00_{igt}^{p,np} + \beta_{31}^{p,np} CLOSED\_k00_{igt}^{p,np}$$
$$+ \beta_{41}^{p,np} PRE\_TESTED\_k00_{igt}^{p,np} + \beta_{42}^{p,np} OPEN\_TESTED\_k00_{igt}^{p,np} + \beta_{43}^{p,np} CLOSED\_TESTED\_k00_{igt}^{p,np}$$
$$+ \beta_{51}^{p,np} PRE\_BTEX\_MAX\_k00_{igt}^{p,np} + \beta_{52}^{p,np} OPEN\_BTEX\_MAX\_k00_{igt}^{p,np}$$
$$+ \beta_{53}^{p,np} CLOSED\_BTEX\_MAX\_k00_{igt}^{p,np} + \beta_6 PUBLIC_i + v_g + u_{igjt}, \quad k = 100, 200, 500$$
(4)

where PUBLIC = 1 if public water source, 0 otherwise, and

$$k00_{igt}^{p,np} = PUBLIC_i \cdot v\_k00_{igt}^{p,np} + (1 - PUBLIC_i) \cdot v\_k00_{igt}^{p,np}$$

Given that we have divided the sales data into periods prior to opening, open, and closed, we will measure three impacts: OPEN_k – PRE_k, CLOSED_k – PRE_k and CLOSED_k – OPEN_k. Assuming that the opening of the case is information that there are health risks, or other negative externalities, associated with the LUST site, we expect OPEN_k – PRE_k to be negative. That is, house prices should be lower during the period that the LUST site is opened compared to the period prior to opening. Given that the closing of the site is information that health risks associated with the LUST have been reduced, we expect CLOSED_k – OPEN_k to be positive. That is, house prices should be higher during the period after the LUST site is closed compared to the period during which it is opened. The impact CLOSED_k – PRE_k can be zero if it is perceived that the closure of the LUST site has resulted in the site being returned to its same state prior to opening. This means that the closure of the site resulted in the (perceived) mitigation of all health risks associated with the LUST site and the use of the site is the same as it was prior to opening. The impact CLOSED_k – PRE_k can be negative if either the closure of the site it not perceived to have eliminated all health risks associated with the LUST site or if the end-use of the site has changed and is viewed as more of a disamenity than the end-use prior to opening. It is possible that impact CLOSED_k – PRE_k can be positive if the end-use of the site has changed and is viewed as more of an amenity than the end-use prior to opening.

Formally, for Model 1, these impacts are defined as

$$\text{OPEN\_PRE\_k\_IM} = 100 \cdot \left(\exp\left(\beta_{32} - \beta_{31}\right) - 1\right)\% \quad (5)$$

$$\text{CLOSED\_PRE\_k\_IM} = 100 \cdot \left(\exp\left(\beta_{33} - \beta_{31}\right) - 1\right)\% \quad (6)$$

$$\text{CLOSED\_OPEN\_k\_IM} = 100 \cdot \left(\exp\left(\beta_{33} - \beta_{32}\right) - 1\right)\% \quad (7)$$

Note that the impacts are calculated in this manner because the dependent variable is in logs.

OPEN_PRE_k_IM is interpreted as the average percent change in house prices when a LUST site in the k meter buffer opens, ceteris paribus. CLOSED_PRE_k_IM is interpreted as the average percent difference in house prices when a LUST site in the k meter buffer is closed compared to before it opened, ceteris paribus. CLOSED_OPEN_k_IM is interpreted as the average percent difference in house prices when a LUST site in the k meter buffer is closed compared to before it is opened, ceteris paribus. These impacts are partial elasticities.

For Model 2, we will calculate impacts for sites that are not tested (the same as above), for sites that are tested with a btex_max concentration of zero and with a btex_max concentration of 10,000 (90^{th} percentile of LUST sites with positive values of btex_max concentrations). The impacts for tested sites with zero concentration are

OPEN_PRE_k_IM $= 100 \cdot \left(\exp\left(\beta_{32} + \beta_{42} - \beta_{31} - \beta_{41}\right) - 1\right)\%$ (8)

CLOSED_PRE_k_IM $= 100 \cdot \left(\exp\left(\beta_{33} + \beta_{43} - \beta_{31} - \beta_{41}\right) - 1\right)\%$ (9)

CLOSED_OPEN_k_IM $= 100 \cdot \left(\exp\left(\beta_{33} + \beta_{43} - \beta_{32} - \beta_{42}\right) - 1\right)\%$ (10)

In this case, OPEN_PRE_k_IM is interpreted as the average percent change in house prices when a LUST site with zero btex_max concentration in the k meter buffer opens, ceteris paribus (and given that there are no other LUST sites with higher btex_max concentrations within the k meter buffer). CLOSED_PRE_k_IM is interpreted as the average percent difference in house prices when a LUST site with zero btex_max concentration in the k meter buffer is closed compared to before it opened, ceteris paribus (and given that there are no other LUST sites with higher btex_max concentrations within the k meter buffer). CLOSED_OPEN_k_IM is interpreted as the average percent difference in house prices when a LUST site with zero btex_max concentration in the k meter buffer is closed compared to before it is opened, ceteris paribus (and given that there are no other LUST sites with higher btex_max concentrations within the k meter buffer).

The impacts for tested sites with a concentration of 10,000 are

OPEN_PRE_k_IM $= 100 \cdot \left(\exp\left(\beta_{32} + \beta_{42} + \beta_{52} - \beta_{31} - \beta_{41} - \beta_{51}\right) - 1\right)\%$ (11)

CLOSED_PRE_k_IM $= 100 \cdot \left(\exp\left(\beta_{33} + \beta_{43} + \beta_{53} - \beta_{31} - \beta_{41} - \beta_{51}\right) - 1\right)\%$ (12)

CLOSED_OPEN_k_IM $= 100 \cdot \left(\exp\left(\beta_{33} + \beta_{43} + \beta_{53} - \beta_{32} - \beta_{42} - \beta_{52}\right) - 1\right)\%$ (13)

In this case, OPEN_PRE_k_IM is interpreted as the average percent change in house prices when a LUST site with a btex_max concentration of 10,000 in the k meter buffer opens, ceteris paribus (and given that there are no other LUST sites with higher btex_max concentrations within the k meter buffer). CLOSED_PRE_k_IM is interpreted as the average percent difference in house prices when a LUST site with a btex_max concentration of 10,000 in the k meter buffer is closed compared to before it opened, ceteris paribus (and given that there are no other LUST sites with higher btex_max concentrations within the k meter buffer). CLOSED_OPEN_k_IM is interpreted as the average percent difference in house prices when a LUST site with a btex_max concentration of 10,000 in the k meter buffer is closed compared to before it is opened, ceteris paribus (and given that there are no other LUST sites with higher btex_max concentrations within the k meter buffer).

In Model 3, impacts are differentiated by public versus private water sources. Hence, the impacts for this model are similar to those given in equations (5) – (13) except that there are two sets: for units with public and private water sources. Again, we might expect the impacts to units with private water sources to be larger than those for units with public water sources since potential health risks from groundwater contamination are higher.

For this approach to be useful, it is important that the public is aware of the toxic nature of the LUST site and the possible health effects. It is an interesting question as to how residents become informed about the risks associated with UST sites (once a leak has occurred) since there is generally not as much publicity about them as there is for Superfund sites. Another interesting issue concerns perceived versus actual risk. For example, Brownfield sites (including some LUST sites) are defined as properties that are underutilized due to perceived or actual risk from contamination. If the risk is only perceived, it can still cause property values to decline. If the property is "cleaned up" and redeveloped, this might lead to a rise in property values even though there has not been a decline in actual health risk. Still, there is an economic benefit to local residents since their properties have increased in value (see Gayer and Zabel (2002) for a detailed analysis of objective versus perceived risk).

5. RESULTS

One problem with the 100 meter buffer is that there can be very few observations available to identify the different LUST impacts. For this reason, we merge the data for Baltimore and Frederick Counties to maximize the number of observations available to identify the LUST impacts that are differentiated by water source. We feel that while these are probably separate housing markets, they are likely to be fairly similar so that pooling will not result in significant bias particularly since we allow all regression coefficients other than those capturing LUST impacts to vary across the two counties. Running a separate regression for Baltimore City County will allow us to determine if the impact of LUSTS is different in urban versus non-urban markets.

Table 3 gives the number of observations available to identify each LUST impact. For the Baltimore and Frederick county dataset, one can see that there are very few observations to identify the 100 meter buffer LUST impacts for units with non-public water sources. We only use the 200 and 200-500 meter buffers for this model. Still, there are enough observations to identify the 100 meter buffer impacts when water source is not differentiated (Models 1 and 2). For the Baltimore City County dataset, there are very few observations to identify the 100 meter buffer LUST impacts so only the 200 and 200-500 meter buffers are used for Models 1 and 2.

The dependent variable for the hedonic regressions is the natural log of house prices. Explanatory variables include quarterly time dummies, age and its square, the log of lot size (in acres) and its square, the log of structure (in square feet) and its square, dummy variables indicating 2, 3, and more than 3 full baths, 1 and more than 1 half bath, the presence of an attic or attached garage, whether the house has a split foyer with 2 levels of living area or is a split level with 3 or more levels of living area and a dummy variable indicating whether the dwelling grade is low cost, economy, or fair. We also include the distance to the nearest major road, open space, surface water body, and nearest commercial district. Finally, a binary variable that indicates the presence of registered tanks with in 500 meters, the number of tanks within 500 meters and its square are included as explanatory variables. For the Baltimore and Frederick Counties dataset, we include block group fixed effects. For the Baltimore City County dataset, we include census tract fixed effects. We use these rather than block group fixed effects because there are not enough sales across block groups in Baltimore City County to be able to accurately identify these effects.

The results for Model 1 are given in Table 4. Separate results are presented for Baltimore and Frederick Counties and for Baltimore City County. Included are the coefficient estimates for the LUST variables in Model 1 and the associated impacts given in equations (5) – (7). For Baltimore and Frederick Counties dataset, we estimate the model with the 100, 100-200, and 200-500 meter buffers. For the Baltimore City County dataset, there are very few observations within one hundred meters of LUST sites so we estimate the model with the 200 and the 200-500 meter buffers. For comparison, we also do this using the Baltimore and Frederick Counties dataset.

In only one case are the PRE_k, OPEN_k and CLOSED_k variables jointly significant at the five percent level (the 200 meter buffer for Baltimore/Frederick Counties). The OPEN-PRE, CLOSED-PRE, and CLOSED-OPEN impacts are significant in only a few cases. In one case, the prices of houses within 200 meters of a LUST site in Baltimore City County were, on average, 9.8% lower after closure as compared to their value prior to discovery. But note that the bulk of this drop occurred when comparing sales after closure to those after discovery (the OPEN_PRE impact is -2.387 whereas the CLOSED_OPEN impact is -7.639 though neither is significant). While the negative impact of discovery could have taken time to be capitalized into house prices, typically one would expect that the largest drop in prices to occur before the site is closed. In another case, the 200-500 meter buffer for Baltimore and Frederick Counties, prices actually rise upon discovery and then fall upon closure of the LUST site.

The results for Model 2 are given in Table 5. Included are the coefficient estimates for the LUST variables in Model 2 and the associated impacts given in equations (5) – (13).

For both the Baltimore and Frederick Counties dataset and the Baltimore City County dataset, we only estimate the model with the 200 and the 200-500 meter buffers. There are few significant impacts when using the Baltimore and Frederick Counties dataset. On the other hand, we see some significant effects, both statistically and economically, when the Baltimore City County data are used. First, for the units within two hundred meters of a LUST site that was not tested, the price falls by close to 4% when the site is opened and falls by an additional 1.5% when it is closed though these impacts are not significantly different from zero. Next, for the units within the two hundred to five hundred meter buffer of a LUST site that was not tested, the price falls by 10.8% when the site is opened and increases by an additional 6.8% when it is closed (the OPEN – PRE and CLOSED – PRE impacts are significantly different from zero at the 10% level or better).

Second, for the units within 200 meters of a LUST site that was tested with a zero contamination level, the price falls by 11.9% when the site is opened and this is significant at the 1% level. This drop is nearly completely recovered when the site is closed.

For the units within two hundred meters of a LUST site that was tested with a contamination level of 10,000 ppb, the price falls by close to 7.5% when the leak case is opened. Prices are still lower by 1.6% when the case is closed compared to prior to the opening of the LUST site. While these results show substantial impacts of the LUST site, it is unexpected that the impact would be smaller for the site with a high level of groundwater contamination compared to the one with no contamination. The price impacts in the 200 to 500 meter buffer are also counter-intuitive as the price rises when the LUST case is opened but then falls when it is closed both when the LUST site has zero contamination and a contamination level of 10,000 ppb.

The specification in Model 3 differentiates LUST impacts based on whether units get their water from public or private water sources. We anticipate that the impacts should be larger for the latter scenario since the potential health risks from the local water source are higher. This model can only be estimated using the data from Baltimore and Frederick Counties since all units in Baltimore City County get their water from public water sources. The results are presented in Table 6. Since the large majority of houses are served by public water sources, the impacts on units served by public water sources are similar to results for Model 2. That is, there is no significant evidence of LUST impacts.

Almost all LUST sites that were within 500 meters of a unit that sold that was served by a private water source were tested because the primary exposure path of concern and potentially exposed populations (i.e., nearby homes) are both present. There are a few cases where units that sold that were served by private water sources were within 500 meters of a LUST site that was not tested but all of these sales took place after the LUST site was closed. This means that we only calculate impacts for units with private water sources that were near tested LUST sites since there were no transactions prior to the closure of non-test LUST sites. The results for the impacts of tested LUST sites within the 200 meter buffer are counter-intuitive with prices going up when sites are open. This is true whether the contamination level was zero or 10,000 ppb. The results for the 200 - 500 meter buffer make more sense as prices fall by 3.7% when the tested LUST site with zero contamination opens and then fall by another 4.6% when the site is closed. Prices also fall by 3.7% when the tested LUST site with a contamination level of 10,000 ppb opens and then fall by another 4.2% when the site is closed.

Some of the above counter-intuitive results make one wonder about how a high btex_max concentration test result would affect transaction rates. To investigate this issue, we calculate the block group transaction rate in each quarter in Baltimore and

Frederick Counties and the census tract transactions rate in each quarter in Baltimore City County. We then regress this variable on the LUST site variables, quarterly dummies, and block group (or census tract) fixed effects. The results for the LUST variables are given in Table 7.[6] Generally, the impacts are not significant. Thus there is a little evidence that units close to LUST sites with high contamination levels are less likely to sell.

A shortcoming of this analysis is that we do not include block groups or census tracts with no sales. A complete analysis would include these in the regressions. Further, there is a potential reverse causality problem in that new development might lead to LUST site discoveries. But this is not likely to lead to an endogeneity problem given the timing of events. That is, LUST site discovery is likely to occur in the beginning stages of development and transactions do not take place until at least a year after this (i.e., LUST site discovery precedes the transaction date and hence transactions cannot cause LUST site discovery).

For Baltimore and Frederick Counties, the overall evidence shows no significant impact of the opening or closure of LUST sites on house prices regardless of whether units were served by public or private water sources. There is some mild evidence of impacts in Baltimore City County. This might lead one to believe that LUST sites are more likely to have an impact in an urban environment than a non-urban environment. One possible explanation for this result is the relative ease of information dissemination in an urban versus a non-urban area.

---

[6] In Table 7, we include the partial elasticities rather than the impacts given in equations (5) – (13) since the dependent variable is binary.

For LUST impacts to be capitalized into prices, it is important that the public is aware of the toxic nature of the LUST site and the possible health effects. It may well be the case that there is little information about some of these LUST sites and hence it is not surprising that these sites have little impact on prices. Some LUST sites have received significantly more publicity than most. Clearly, if any sites are going to display significant impacts it would be this subset for which the public is most likely to be aware of the potential health effects. There are twenty-three LUST cases in Baltimore and Frederick Counties that are posted on the MDE "Oil Control Program Remediation Sites" website. These can be considered to be sites that have received significant publicity since information about a LUST site is posted on the MDE webpage when there is significant public concern.

As expected, these sites are more contaminated than the LUST sites that are not listed on the MDE website. First, all 23 publicized sites were tested, whereas only 72% of the non-publicized sites were tested. Second, the average btex_max concentration of the posted sites is 33,954 ppb whereas the average for the non-posted sites that were tested is 13,742 ppb. So the impact of these sites on house values is due to a combination of the extra publicity they received and the fact that they are more contaminated sites than the non-publicized sites. The case number, spill location, city, and opening dates for the publicized sites are listed in Table 8. Only three of these cases have closed and only one of these dates is covered in our dataset.[7] Thus it is not possible to estimate the impact of the closing of these publicized sites on house prices in Baltimore and Frederick Counties.

[7] Case number 04-2121BA4 closed on September 11, 2007, case number 06-0317FR closed on June 17, 2008, and case number 06-0826BA2 closed on January 25, 2008.

Here, we estimate a version of Model 1. Because of the small number of sales close to these LUST sites, we use 500 meter and 500-1000 meter buffers. The impact of the non-publicized sites is small and not significantly different from zero; the p-value for the F-test of the joint significance of the six LUST coefficients is 0.553. For this reason, only the results for the publicized LUST sites are given in Table 9. For the publicized sites, the p-value for the F-test of the joint significance of the four LUST impacts is 0.155. The impact when a publicized LUST site opens is a drop in prices of 1.93% in the 500 meter ring and 5.3% in the 500-1000 meter ring. The p-values for these impacts are 0.376 and 0.030, respectively. It is contrary to expectations that the impact is larger in the 500-1000 meter ring versus the 500 meter ring. Still, this provides some evidence of a small drop in prices when a publicized LUST site is opened.

Given that the publicity of these sites is important in determining their impact on house prices, it might be that the impact of the publicized sites increases the longer it has been opened. We hence allow the impact to vary depending on whether the sale occurs within one year of the site being opened, OPEN_1, between one and two years, OPEN_2, and for three or more years of the site being opened, OPEN_3G. To ensure that there are enough observations to identify each impact, we use the 1000 meter buffer. The results for the publicized LUSTs are given in Table 9. We see that the coefficient actually increases for sites that have just opened but then the coefficients decrease over the next two periods such that prices are 5.8% lower for houses that sell three or more years after the publicized LUST was opened compared to houses that sell within one year of the opening.

Next, we consider another way of grouping the impacts, a sale occurs within three years of opening, OPEN_13, three to six years after opening, OPEN_46, and more than six years after opening, OPENG6. Results for the publicized LUST sites are given in Table 9. Again, the coefficient increases (relative to pre-opening) for impacts in the first three years since opening but then decreases substantially after that. Prices are 12.1% lower for houses that sell more than six years after the publicized LUST was opened compared to houses that sell within three years of the opening. The large decrease for sites that are opened for more than six years is picking up the subset of six sites that were opened in or before 2000.

Finally, we look at the possibility of being able to accurately estimate the impacts of individual sites. The key is finding individual sites with enough proximate sales to identify the LUST effects. In Table 8, we list the number of sales within 1000 meters of each publicized site prior to and after opening. Eight of the publicized sites have sufficient observations to be analyzed individually. Included is the Jacksonville Exxon gas station in the city of Phoenix in Baltimore County. This site has received a lot of publicity

> "Phoenix was the location of a January 2006 Exxon gas leak, where over 26,000 gallons of gas slowly seeped out of a punctured pipe at a station at the intersection of Maryland Route 145 and Maryland Route 146. The area affected by the gas leak was about a half-mile downhill from the location of the gas station. Six wells were contaminated, and 62 residential wells showed traces of MTBE. The state filed a $12 million suit against Exxon in April 2006. In September 2008, the state settled case with Exxon, imposing a $4 million civil penalty. In addition, about

> 300 Jacksonville residents sought compensatory and punitive damages from Exxon worth several billion dollars. In March 2009, a Baltimore County jury found Exxon liable and awarded various amounts of compensatory damages to the plaintiffs." http://en.wikipedia.org/wiki/Jacksonville,_Maryland

One problem with the Jacksonville Exxon site is that there are two other publicized sites in close proximity; the Amoco station in Phoenix and the Jacksonville CITGO station. This makes it difficult to isolate the impact of each site so we combine them into one indicator.[8] This is also the case for the Green Valley Garage and the Green Valley Citgo station. Hence we combine these two as well, leaving us with five publicized sites.

We estimated a simple version of Model 1 with binary indicators of a sale within 1000 meters prior to and after the opening of each of the five publicized sites. As before, we also included variables that captured the number of LUST sites within 1000 meters of each sale where the sales date is prior to the opening, during the opening, and after the closure of all other LUST sites in the Baltimore and Frederick County data set. The results for the five publicized LUST sites are given in Table 10. The impact on house prices from the opening of the Jacksonville Exxon site is a decline of 12.4%. This impact is significant at the 1% level. Of the other four cases, the impact of opening the site is actually positive in three cases and significant in two of these three. It is unlikely that these estimates are causal impacts of the site openings. In the final case, the Farmers & Mechanics Bank in Union Bridge, Frederick County, the impact is a drop in prices of 5.4% (significant at 1%).

Finally, the above description of the Jacksonville Exxon site indicates that the impact of the contamination was approximately one half-mile downhill from the gas

[8] The results do not change much when we consider the Jacksonville Exxon site by itself.

station. Thus, one might believe that the impact on house prices might have been centered on this impact area.

We looked at the contamination plume to see if we could identify an impact zone. While the plume did have a directional focus, it was not narrow enough to be able to identify a fairly targeted “impact zone.” Instead, we added a second buffer to the Jacksonville Exxon site. This buffer extends from 1000 to 2000 meters from this site. The results are given in columns 4-6 in Table 10. There was a small drop in house prices of 3.5% (the p-value is 0.0848). This is weak evidence that the impact was felt beyond 1000 meters from the actual site.

In conclusion, a typical site with little publicity is unlikely to have a significant impact on prices. Even among sites that receive a fair amount of publicity, impacts on house prices are generally not statistically and economically significant (and are even positive in some cases). Only in the most publicized case do we find both economically and statistically significant impacts.

6. CONCLUSION

In this analysis, we have investigated the impact of LUST sites on house prices in three counties in Maryland for the 1996 – 2007 period. We estimate a hedonic house price model that allows the impact of LUST sites to vary within specified distance buffers. We control for the effect of LUST sites on house prices prior to their discovery. We then calculate the impact of the opening and closing of LUST sites on house prices relative to their pre-discovery capitalized value. The hedonic model includes a large number of structural characteristics, neighborhood characteristics such as the distance to the nearest commercial area and the number of registered USTs within 500 meters, quarterly time dummies, and either block group or census tract fixed effects. The latter terms control for unobserved (time invariant) amenities/disamenities in the block group or census tract that affect house prices. This makes it more likely that the LUST impacts we estimate are not biased because of omitted neighborhood characteristics and hence can be considered to be causal effects.

We allow the impacts of the LUST sites to vary by contamination level. Further, we estimate separate effects depending on whether or not household drinking water comes from local ground water since this should impact the potential health risks of the LUST sites. In order to maximize the number of observations to identify LUST impacts for units with private wells, we combine the data from Baltimore and Frederick Counties (all units in Baltimore City County receive their drinking water from public sources). Generally, we find little impact of LUST sites on house values in Baltimore and Frederick Counties. This is even true for units that receive their drinking water from private wells. There is some evidence of a significant impact in Baltimore City County; the most urban area in our data set. We speculate that this might be because information on LUST sites is more readily disseminated in an urban area.

Given the importance of information in the process of the capitalization of the impact of LUST sites into house values, we consider a subset of the most publicized sites. In this case we do find evidence of significant impacts; house values fall by up to 5.3%. We also find that the impact increases the longer a publicized LUST site has been open; up to 12.1% for sites open for more than six years. Finally, we look at five of these publicized sites with enough proximate sales to be able to identify individual impacts.

For the most publicized LUST site in our data set; the Jacksonville Exxon gas station in the city of Phoenix in Baltimore County, the prices for nearby houses dropped by 12.4% on average after this site was opened.

The conclusion that we draw from this analysis is that the average LUST site is unlikely to have a significant impact on house prices. However, this can mask significant impacts for the most publicized (and more contaminated) LUST sites. Thus any benefits that accrue from cleaning up LUST sites, as reflected in residential property values, are most likely confined to the most publicized sites.

REFERENCES

Alberini, Anna (2007), "Determinants and Effects on Property Values of Participation in Voluntary Cleanup Programs: The Case of Colorado," *Contemporary Economic Policy*, 25(3): 415-432.

Bowen, Mark J. Salling, Kingsley E. Haynes, Ellen J. Cyran (1995), "Toward Environmental Justice: Spatial Equity in Ohio and Cleveland," *Annals of the Association of American Geographers*, 85(4): 641-663

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

Dotzour, M. (1997), "Groundwater Contamination and Residential Property Values," *The Appraisal Journal*, 65(3): 279–85.

Farber, Stephen (1998), "Undesirable facilities and property values: a summary of empirical studies," *Ecological Economics*, 24: 1-14.

Fotheringham, A.S., M.E. Charlton, and C. Brundson (1998), "Geographically weighted Regression: a Natural Evolution of the Expansion Method for Spatial Data Analysis," *Environment and Planning A* 30: 1905-1927.

Gayer, Ted, and J.E. Zabel (2002), "Perceived versus Objective Environmental Risks: Estimating the Benefits of Cleaning Up Superfund Sites in Woburn, Massachusetts," mimeo, Tufts University.

Guntermann, K. L. (1995), "Sanitary Landfills, Stigma and Industrial Land Values," *Journal of Real Estate Research*, 10(5): 531–42.

Howland, Marie (2000), "The Impact of Contamination on the Canton/Southeast Baltimore Land Market," *Journal of the American Planning Association*, 66(4): 411-420.

Ihlanfeldt, K. R. and Laura O. Taylor (2004),"Externality Effects of Small Scale Hazardous Waste Sites: Evidence from Urban Commercial Property Markets," *Journal of Environmental Economics and Management*, 47(1): 117-139.

Jackson, Thomas O. (2001), "The Effects of Environmental Contamination on Real Estate: A Literature Review," *Journal of Real Estate Literature* 9(2): 93-116.

Jackson, Thomas O. (2002), "Environmental Contamination and Industrial Real Estate Prices," *Journal of Real Estate Research* 23(2): 179-199.

Khan, Faisal I., Tahir Husain, Ramzi Hejazi (2004), "An overview and analysis of site remediation technologies," *Journal of Environmental Management*, 71: 95-122.

Kiel, K. and M. Williams (2007), "The impact of Superfund sites on local property values: Are all sites the same?" *Journal of Urban Economics* 61: 170-192.

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

Lange, D., and S. MacNeil (2004), "Brownfield Development: Tools for Stewardship," *Journal of Urban Planning and Development,* 130(2): 109-16.

Longo, Alberto and Anna Alberini (2006), "What are the Effects of Contamination Risks on Commercial and Industrial Properties? Evidence from Baltimore, Maryland," *Journal of Environmental Planning and Management,* 49(5): 713-737.

McGrath, D.T. (2000), “Urban Industrial Land Redevelopment and Contaminated Risk,” *Journal of Urban Economics* 47(3): 414-442.

Page, G. W. and H. Rabinowitz (1993), “Groundwater Contamination: Its Effects on Property Values and Cities,” *Journal of the American Planning Association*, 59(4): 473–81.

Patchin, P. J. (1994), “Contaminated Properties and the Sales Comparison Approach,” *The Appraisal Journal*, 62(3): 402–9.

Rosen, S. (1974), “Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition,” *Journal of Political Economy*, 82: 34-55.

Schoenbaum, Miriam (2002), “Environmental Contamination, Brownfields Policy, and Economic Redevelopment in an Industrial Area of Baltimore Maryland,” *Land Economics* 78(1): 60-71.

Sementelli, A., and R. Simons (1997), “Regulation of Leaking Underground Storage Tanks: Policy Enforcement and Unintended Consequences,” *Economic Development Quarterly* 11(3): 236-48.

Sigman, Hilary (2005), “Environmental Liability and Redevelopment of Old Industrial Sites,” Working paper, Rutgers University.

Simons, Robert A. (1998), *Turning Brownfields into Greenbacks*, Washington, D.C.: Urban Land Institute.

Simons, R. A., and A. J. Sementelli (1997), “Liquidity Loss and Delayed Transactions with Leaking Underground Storage Tanks,” *The Appraisal Journal*, 65(3): 255–60.

Simons, R. A., W. M. Bowen, and A. J. Sementelli (1997), "The Effect of Underground Storage Tanks on Residential Property Values in Cuyahoga County, Ohio," *Journal of Real Estate Research*, 14(1/2): 29–42.

Simons, Robert A., W. Bowen, and A. Sementelli (1999), "The Price and Liquidity Effects of UST Leaks from Gas Stations on Adjacent Contaminated Property," *The Appraisal Journal* 67(2): 186-94.

Thayer, M., H. Albers and M. Rahmatian (1992), "The Benefits of Reducing Exposure to Waste Disposal Sites: A Hedonic Housing Value Approach," *The Journal of Real Estate Research*, 7(3): 265-282.

US EPA (2004) – United States Environmental Protection Agency, "How to Evaluate Alternative Cleanup technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers," EPA 510-R-04-002, www.epa.gov/oust/pubs/tums.htm, accessed July 23, 2008.

Zabel, J.E. (2003), "The Economics of Brownfields – with an Application to Somerville Massachusetts," unpublished paper, Economics Department, Tufts University.

Table 1 Dates of Opened and Closed LUST sites		
Year	Opened	Closed
1996	21	6
1997	12	11
1998	15	8
1999	14	9
2000	12	11
2001	13	10
2002	11	4
2003	22	13
2004	25	19
2005	41	32
2006	25	19
2007	8	16
2008	0	4
Total	219	149

Table 2 **Summary Statistics for Housing Data**				
	Mean	Std Dev	Minimum	Maximum
Variable	Baltimore City County			
Nominal House Price (in $1,000s)	158.304	147.815	20.06	2520
Real House Price (in $1,000s, base is 2000)	147.037	133.042	17.441	2306.848
Lot Size (Acres)	0.205	0.148	0.003	5.280
Living Area (1000's of sq ft)	1.719	0.779	0.104	7.911
Age of House	71.186	20.389	0	206
Number of Full Bathrooms	1.579	0.800	1	10
Number of Half Bathrooms	0.294	0.510	0	5
1 if split foyer 2 levels of living area	0.006	0.080	0	1
1 if split level 3 or more levels of living area	0.007	0.086	0	1
1 if Attic or Attached Garage	0.080	0.271	0	1
1 if dwelling grade is low cost, economy, or fair	0.764	0.424	0	1
Nearest open space in 1,000s meters	0.457	0.291	0	1.454
Nearest surface water body in 1,000s meters	2.263	1.233	0.027	5.592
Nearest major road in 1,000s meters	2.524	1.111	0.017	5.132
Nearest commercial zone in 1,000s meters	0.368	0.250	0	1.281
Number of registered tanks within 500 meters	2.537	2.771	0	21
	Baltimore County			
Nominal House Price (in $1,000s)	241.483	182.734	22.575	3300
Real House Price (in $1,000s, base is 2000)	226.677	161.197	20.280	2740.689
Lot Size (Acres)	0.512	0.874	0.002	10
Living Area (1000's of sq ft)	1.789	0.852	0	7.976
Age of House	38.217	26.056	0	206
Number of Full Bathrooms	1.711	0.738	1	8
Number of Half Bathrooms	0.550	0.549	0	5
1 if split foyer 2 levels of living area	0.068	0.251	0	1
1 if split level 3 or more levels of living area	0.093	0.290	0	1
1 if Attic or Attached Garage	0.401	0.490	0	1
1 if dwelling grade is low cost, economy, or fair	0.340	0.474	0	1
Nearest open space in 1,000s meters	0.540	0.597	0	7.296
Nearest surface water body in 1,000s meters	2.470	1.669	0	14.656
Nearest major road in 1,000s meters	1.949	1.772	0.001	12.139
Nearest commercial land use in 1,000s meters	0.663	0.676	0	6.775
Number of registered tanks within 500 meters	1.174	2.013	0	18
	Frederick County			
Nominal House Price (in $1,000s)	270.828	143.943	25	2901.8
Real House Price (in $1,000s, base is 2000)	258.237	120.710	26.411	2901.8
Lot Size (Acres)	0.700	1.129	0.016	10
Living Area (1000's of sq ft)	1.997	0.801	0.348	7.929
Age of House	20.698	27.249	0	207
Number of Full Bathrooms	1.962	0.661	1	7
Number of Half Bathrooms	0.644	0.514	0	5
1 if split foyer 2 levels of living area	0.078	0.269	0	1
1 if split level 3 or more levels of living area	0.053	0.224	0	1
1 if Attic or Attached Garage	0.463	0.499	0	1

Table 2 Summary Statistics for Housing Data				
	Mean	Std Dev	Minimum	Maximum
1 if dwelling grade is low cost, economy, or fair	0.098	0.297	0	1
Nearest open space in 1,000s meters	1.700	1.660	0	10.744
Nearest surface water body in 1,000s meters	3.977	2.330	0	12.664
Nearest major road in 1,000s meters	2.545	2.450	0.004	17.760
Nearest commercial zone in 1,000s meters	0.947	0.987	0	9.697
Number of registered tanks within 500 meters	0.644	1.772	0	16

Table 3
Buffer Counts

				public water			non-public water		
Buffer	all	tested	cont>0	all	tested	cont>0	all	tested	cont>0
	Frederick and Baltimore Counties								
PRE_100	155	126	111	138	109	98	17	17	13
OPEN_100	76	72	70	60	56	55	16	16	15
CLOSED_100	77	27	22	74	26	22	3	1	0
PRE_200	720	512	464	634	426	395	86	86	69
OPEN_200	308	262	255	264	218	215	44	44	40
CLOSED_200	421	152	141	402	144	137	19	8	4
PRE_100_200	573	392	359	504	323	303	69	69	56
OPEN_100_200	233	191	186	204	162	160	29	29	26
CLOSED_100_200	344	125	119	328	118	115	16	7	4
PRE_200_500	4190	3372	3038	3724	2926	2681	466	446	357
OPEN_200_500	1696	1380	1359	1549	1233	1224	147	147	135
CLOSED_200_500	2424	1225	1122	2303	1165	1071	121	60	51
Baltimore City County									
PRE_100	34	26	26						
OPEN_100	11	9	9						
CLOSED_100	32	2	2						
PRE_200	179	122	122						
OPEN_200	76	57	57						
CLOSED_200	291	39	39						
PRE_100_200	145	96	96						
OPEN_100_200	65	48	48						
CLOSED_100_200	260	37	37						
PRE_200_500	1245	938	935						
OPEN_200_500	457	302	302						
CLOSED_200_500	2054	538	532						

Table 4 **Results for Model 1**			
	Balt/Fred Counties		Balt City
	(1)	(2)	(3)
Variable/Impact	100 Meter Buffer		
PRE	-0.072*		
OPEN	-0.026		
CLOSED	-0.037		
p-value for joint sig	0.067		
	200 Meter Buffer		
PRE		-0.029**	0.048
OPEN		-0.015	0.024
CLOSED		-0.024	-0.056
p-value for joint sig		0.025	0.239
	100-200 Meter Buffer		
PRE	-0.019		
OPEN	-0.012		
CLOSED	-0.021		
p-value for joint sig	0.159		
	200-500 Meter Buffer		
PRE	0.001	0.001	0.028
OPEN	0.016	0.016	0.016
CLOSED	-0.008	-0.008	-0.004
p-value for joint sig	0.243	0.239	0.518
	Percent Impacts for 100 meter buffer		
OPEN_PRE	4.713		
CLOSED_PRE	3.613		
CLOSED_OPEN	-1.051		
	Percent Impacts for 200 meter buffer		
OPEN_PRE		1.396	-2.378
CLOSED_PRE		0.514	-9.836**
CLOSED_OPEN		-0.870	-7.639
	Percent Impacts for 100-200 meter buffer		
OPEN_PRE	0.704		
CLOSED_PRE	-0.250		
CLOSED_OPEN	-0.947		
	Percent Impacts for 200-500 meter buffer		
OPEN_PRE	1.523*	1.523*	-1.126
CLOSED_PRE	-0.838	-0.858	-3.112
CLOSED_OPEN	-2.326	-2.346*	-2.009
Observations	112502	112502	24296
Number of bg/tract	602	602	128
Adj R-squared	0.788	0.787	0.442
SER	0.205	0.205	0.410
** p<0.01, * p<0.05			

Table 5 **Regression Results for Model 2**				
	Baltimore/Fred Counties		Baltimore City County	
	200	200-500	200	200-500
Variable/Impact	Without Testing			
PRE	-0.011	-0.005	-0.010	0.051*
OPEN	-0.026	0.054	-0.049	-0.063
CLOSED	-0.019	0.005	-0.065*	0.004
p-values for joint sig	0.706	0.119	0.284	0.198
	With Testing, Contamination = 0			
PRE	-0.046***	-0.002	0.133***	0.008
OPEN	-0.004	0.013	0.006	0.044
CLOSED	-0.034	-0.016	0.125	-0.046
p-values for joint sig	0.032	0.208	0.000	0.426
	With Testing, Contamination = 10,000 (around 90th pctile)			
PRE	-0.043***	-0.001	0.036	0.040
OPEN	-0.007	0.012	0.110	0.088***
CLOSED	-0.029	-0.018	0.020	-0.024
p-values for joint sig	0.033	0.197	0.398	0.006
	Percent Impact, Without Testing			
OPEN – PRE	-1.446	6.050**	-3.913	-10.777*
CLOSED – PRE	-0.784	0.951	-5.386	-4.675*
CLOSED – OPEN	0.672	-4.808	-1.534	6.839
	Percent Impact, With Testing, Contamination = 0			
OPEN – PRE	4.252*	1.586	-11.896***	3.721
CLOSED – PRE	1.191	-1.376	-0.800	-5.231
CLOSED – OPEN	-2.936	-2.915	12.594	-8.631
	Pct Impact, With Testing, Contam = 10,000 (around 90th pctile)			
OPEN – PRE	3.652*	1.262	-7.454	4.910
CLOSED – PRE	1.366	-1.735	-1.553	-6.288*
CLOSED – OPEN	-2.206	-2.960**	6.376	-10.674**
*** p<0.01, ** p<0.05, * p<0.10				

Table 6
Regression Results for Model 6
Baltimore and Frederick Counties

	Public Water Source		Non-Public Water Source	
	200	200-500	200	200-500
Variable/Impact	Without Testing			
PRE	-0.010	-0.002		
OPEN	-0.025	0.055*		
CLOSED	-0.018	0.004	-0.082	0.019
p-values for joint sig	0.752	0.176		
	With Testing, Contamination = 0			
PRE	-0.042**	-0.009	-0.046*	0.040**
OPEN	0.004	0.017	-0.018	0.002
CLOSED	-0.036	-0.016	-0.065	-0.044**
p-values for joint sig	0.132	0.101	0.340	0.003
	With Testing, Contamination = 10,000 (around 90th pctile)+			
PRE	-0.044**	-0.010	-0.046*	0.040**
OPEN	-0.002	0.013	-0.018	0.002
CLOSED	-0.033	-0.019	-0.060	0.294**
p-values for joint sig	0.085	0.077	0.000	0.000
	Percent Impact, Without Testing			
OPEN – PRE	-1.504	5.866**		
CLOSED – PRE	-0.830	0.651		
CLOSED – OPEN	0.684	-4.926		
	Percent Impact, With Testing, Contamination = 0			
OPEN – PRE	4.771*	-3.067	2.910	-3.692
CLOSED – PRE	0.578	-1.340	-1.811	-8.015***
CLOSED – OPEN	-4.002	1.782	-4.588	-4.488
	Pct Impact, With Testing, Contam = 10,000 (around 90th pctile)+			
OPEN – PRE	4.271*	-0.322	2.906	-3.692
CLOSED – PRE	1.084	-0.230	-1.407	-7.704***
CLOSED – OPEN	-3.057	0.092	-4.191	-4.166

*** p<0.01, ** p<0.05, * p<0.10
+ The contamination level at which the LUST impact is calculated is 1,000 for the private water source since this is the highest contamination level recorded for these cases

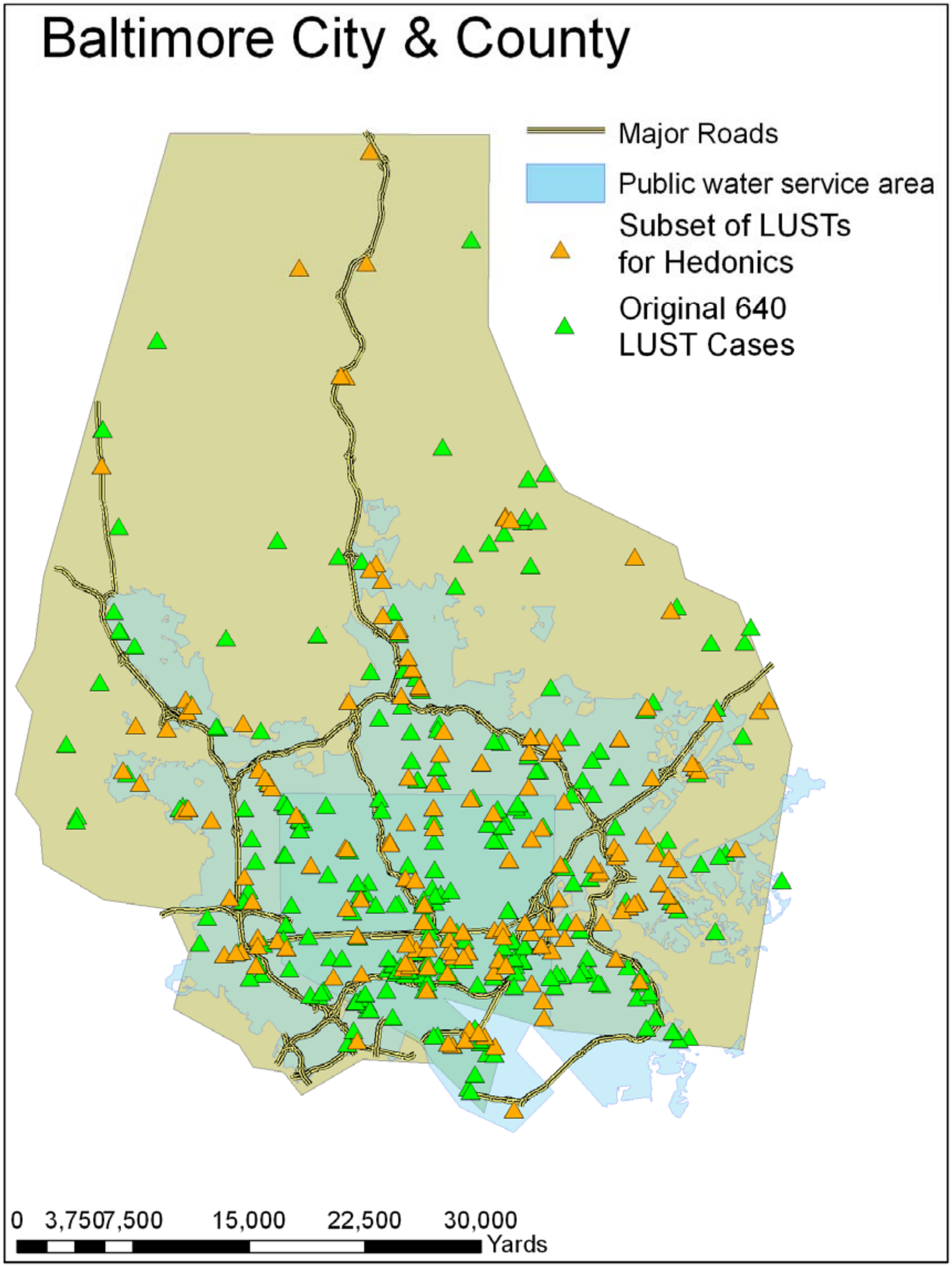
Table 7 **Regression Results Dependent Variable: Number of Transaction Rate**				
	Baltimore/Fred Counties		Baltimore City County	
	200	200-500	200	200-500
Variable/Impact	Without Testing			
PRE	0.253***	0.245***	0.259*	0.366***
OPEN	0.116	0.513***	-0.133	0.536***
CLOSED	0.279**	0.463***	0.362***	0.648***
p-values for joint sig	0.001	0.000	0.000	0.000
	With Testing, Contamination = 0			
PRE	0.430***	0.384***	0.422***	0.120***
OPEN	0.389***	0.434***	0.267	0.135***
CLOSED	0.827***	0.498***	0.321	0.267**
p-values for joint sig	0.000	0.000	0.000	0.000
	With Testing, Contamination = 10,000 (around 90th pctile)			
PRE	0.402***	0.371***	0.571***	0.496***
OPEN	0.371***	0.424***	0.396**	0.221
CLOSED	0.796***	0.465***	0.319*	0.552***
p-values for joint sig	0.000	0.000	0.000	0.000
	Partial Elasticity, Without Testing			
OPEN – PRE	-6.825	13.329**	-15.436	6.705
CLOSED – PRE	1.264	10.850**	4.074	11.119**
CLOSED – OPEN	8.089	-2.479	19.510*	4.415
	Partial Elasticity, With Testing, Contamination = 0			
OPEN – PRE	-2.011	2.464	-6.087	5.592
CLOSED – PRE	19.746*	5.675*	-3.986	8.880
CLOSED – OPEN	21.757	3.211	2.102	10.952
	Partial Elasticity With Testing, Contam = 10,000 (90th pctile)			
OPEN – PRE	-1.529	2.621	-6.916	-10.838*
CLOSED – PRE	19.576**	4.662	-9.913	2.211
CLOSED – OPEN	21.106*	2.041	-2.997	13.050
*** p<0.01, ** p<0.05, * p<0.10				

Table 8 **Publicized Cases in Baltimore and Frederick Counties**				
Case_no	Spill Location	City	Date Opened	# of sales before/after opening
96-2047FR	GRESHAM STORE/FLINTHILL GROCY	ADAMSTOWN	30-Sep-96	2/30
97-0257FR	HAHN TRANSPORT	NEW MARKET	12-Aug-96	47/321*
97-0646FR	BARNES STORE	FREDERICK	8-Oct-96	3/38
00-0575FR	CARL CLINGAN	LIBERTYTOWN	27-Sep-99	20/37
00-1125FR	SHELL	MT. AIRY	28-Dec-99	16/18
00-1183FR	FARMERS & MECHANICS BANK	UNION BRIDGE	11-Jan-00	54/42*
00-1301FR	GREEN VALLEY GARAGE	MONROVIA	9-Feb-00	100/102*
00-1332FR	7-ELEVEN STORE 28961	LIBERTYTOWN	15-Feb-00	21/36
03-1335BA2	FORMER STEBBINS BURNHAM	OWINGS MILLS	10-Mar-03	59/36*
03-1758FR	SHEETZ STORE #176	KNOXVILLE	7-May-03	43/17
04-2121BA4	CROWN MD-81	JOPPA	23-Jun-04	4/2
05-0326BA2	AMOCO STATION #3033	PHOENIX	9-Sep-04	127/38*
05-0522BA3	CHEVRON/EXXON STATION	HEREFORD	25-Oct-04	21/5
05-0834FR	GREEN VALLEY CITGO	MONROVIA	19-Jan-05	214/47*
05-0856BA2	JACKSONVILLE CITGO	JACKSONVILLE	24-Jan-05	129/33*
06-0239FR	MT. PLEASANT CITGO	FREDERICK	21-Sep-05	49/13
06-0245FR	EXXON #26463	FREDERICK	22-Sep-05	116/9
06-0303BA2	EXXON SERVICE STA 2-8077	PHOENIX	6-Oct-05	141/23*
06-0317FR	CIFCO #1 6/10 GAS MART	CLARKSBURG	13-Oct-05	40/9
06-0675FR	JEFFERSON BP	JEFFERSON	9-Feb-06	239/14
06-0825BA2	FORK CITGO #23	KINGSVILLE	31-Mar-06	46/11
06-0826BA2	MARYLAND LINE GARAGE	MD LINE	31-Mar-06	23/4
07-0593FR	GAS MART OF FREDERICK	FREDERICK	16-Feb-07	2/0
Note: * - chosen for individual analysis				

Table 9 Results for Publicized LUST Sites; Baltimore and Frederick Counties			
	500 Meter Buffer		
Variable/Impact			
PRE	0.020		
OPEN	0.000		
p-values for joint sig	0.425		
OPEN – PRE	-1.935		
	500-1000 Meter Buffer		
PRE	0.013		
OPEN	-0.041**		
p-values for joint sig	0.067		
OPEN – PRE	-5.257**		
	1000 Meter Buffer		
PRE		0.015	0.015
OPEN_1		0.035**	
OPEN_2		-0.005	
OPEN_3G		-0.025*	
OPEN_13			0.058**
OPEN_46			0.026
OPEN_G6			-0.070**
p-values for joint sig		0.000	0.000
	Percent Impacts		
OPEN_1 – PRE		2.037	
OPEN_2 – PRE		-1.900	
OPEN_3 – PRE		-3.872**	
OPEN_2 – OPEN_1		-3.858***	
OPEN_3G – OPEN_1		-5.791***	
OPEN_3G – OPEN_2		-2.010	
OPEN_13 – PRE			4.467**
OPEN_46 – PRE			1.100
OPEN_G6 – PRE			-8.151***
OPEN_46 – OPEN_13			-3.224*
OPEN_G6 – OPEN_13			-12.079***
OPEN_G6 – OPEN_46			-9.150***
Observations	112502	112502	112502
Number of bg/tract	602	602	602
Adj R-squared	0.787	0.788	0.788
SER	0.205	0.205	0.205
*** p<0.01, ** p<0.05, * p<0.10			

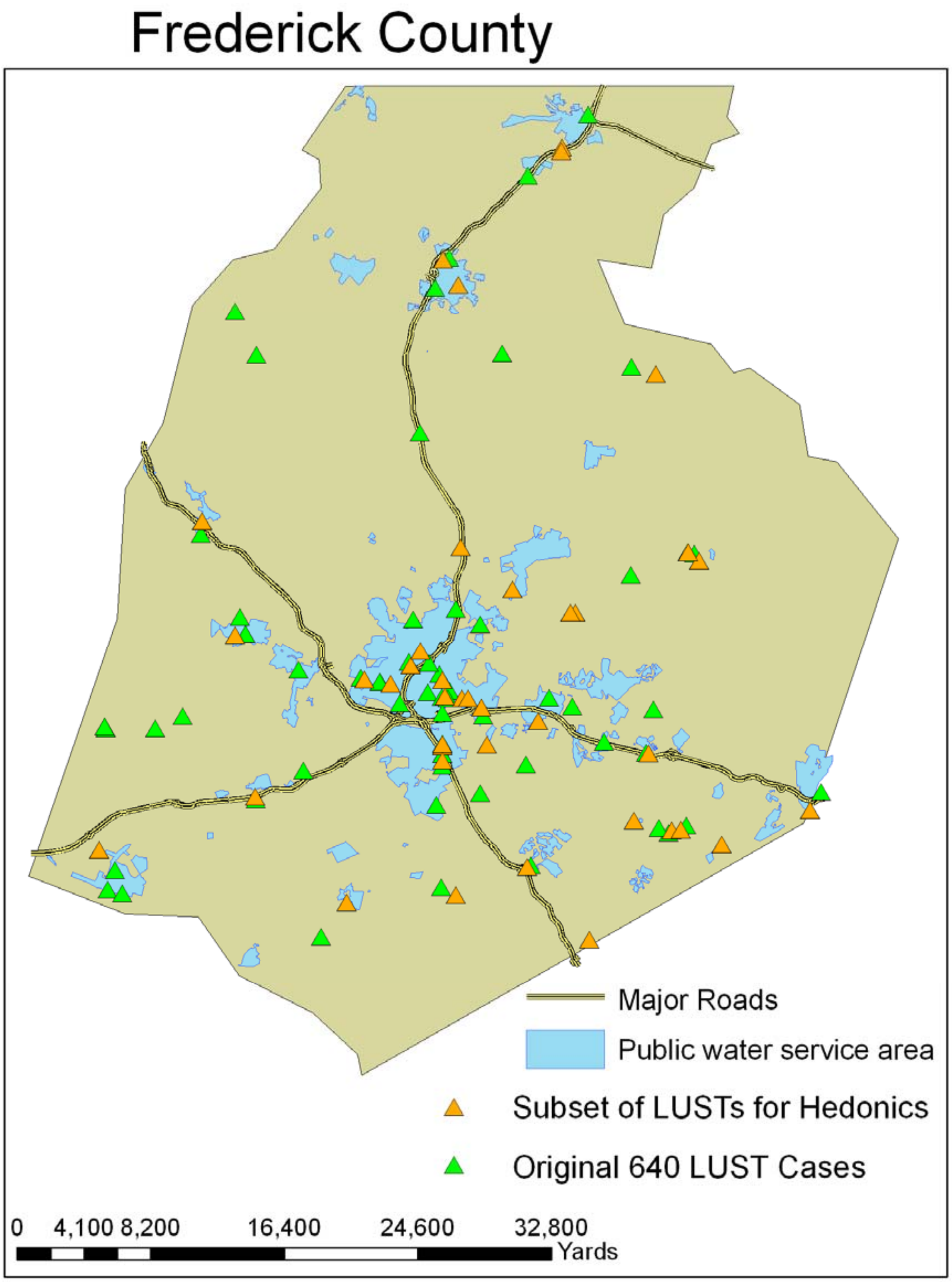
Table 10 Results for Individual Publicized LUST Sites; Baltimore and Frederick Counties						
	1000 Meter Buffer			1000-2000 Meter Buffer		
LUST SITES	PRE	OPEN	IMPACT	PRE	OPEN	IMPACT
	(1)	(2)	(3)	(4)	(5)	(6)
Jacksonville Exxon	0.087	-0.045	-12.358**	0.003	-0.033	-3.537
	(0.076)	(0.038)		(0.022)	(0.023)	
Green Valley Garage/CITGO	-0.023	0.036**	6.015**			
	(0.018)	(0.011)				
Hahn Transport	-0.173**	-0.164**	0.903			
	(0.027)	(0.026)				
Farmers & Mechanics Bank	-0.046**	-0.102**	-5.438**			
	(0.010)	(0.015)				
Former Stebbins Burnham	-0.062	0.070	14.180**			
	(0.167)	(0.154)				
Observations	112502					
Adj R-squared	0.788					
SER	0.205					
Robust standard errors in parentheses						
** p<0.01, * p<0.05						

Figure 1



Baltimore City & County
Major Roads
Public water service area
Subset of LUSTs
for Hedonics
Original 640
LUST Cases
0 3,750 7,500 15,000 22,500 30,000
Yards

Figure 2


Frederick County
Major Roads
Public water service area
Subset of LUSTs for Hedonics
Original 640 LUST Cases
0
4,100
8,200
16,400
24,600
32,800
Yards