PROPERTY VALUE IMPACTS AND RISKS PERCEPTIONS: A HEDONIC

ANALYSIS OF ANNISTON, ALABAMA

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PROPERTY VALUE IMPACTS AND RISKS PERCEPTIONS: A HEDONIC ANALYSIS OF ANNISTON, ALABAMA

Christophe Vincent de Parisot

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PROPERTY VALUE IMPACTS AND RISKS PERCEPTIONS: A HEDONIC ANALYSIS OF ANNISTON, ALABAMA

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Christophe Vincent de Parisot, son of Raoul and Corinne de Parisot, was born on July 11, 1979, in Grande Synthe, France. He graduated from the Cité Scolaire Internationale de Lyon in 1998. He attended the University Claude Bernard of Lyon the same year and graduated with a two-year Biochemistry degree in 2000. In January 2001, he moved to the South of France to attend the Euro American Institute of Technology of Sophia Antipolis to study applied economics. His senior year, he transferred to Auburn University in January 2002 and graduated with a Bachelor of Science in Agricultural Economics in May 2003. He entered The Graduate School, at Auburn University, in January 2004.

THESIS ABSTRACT

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The city of Anniston, and to a larger extent Calhoun County, Alabama, has been affected by two major types of environmental disamenities: polychlorinated biphenyls (PCBs) released into the soils and waterways, and the emission of toxic particles from the Chemical Weapon Incinerator. The Solutia facility in Anniston is one of the two chemical facilities to have produced PCBs in the United States. During its early operational history, the plant disposed of hazardous waste in an unlined landfill on-site. Runoff from the landfill flowed into drainage ditches exiting the plant, contaminating nearby and downstream communities. On the other side of town, only 6 miles west from the Solutia plant lies the Anniston Army Depot. In 1996, the U.S. Army announced publicly the construction of a chemical incinerator at the Depot to dispose of its decaying chemical

weapons. In this study, I explore property value impacts of these disamenities by estimating hedonic price models on an extensive and unique set of data collected from the county. The compiled data contains 9,655 housing records that were geo-coded to allow geographic information system (GIS) techniques to be used in addition to the hedonic technique. In addition, a survey was conducted of individuals buying a house in Calhoun County since January 1993.

To analyze the data, a hedonic price model is applied to calculate percent change in property values for the residents of Calhoun County. Residents' welfare, measured by property value gains and losses, is assessed for time periods, corresponding to different stages of operation at the two major hazardous facilities in West Anniston. Both Solutia's chemical plant and the U.S. Army Depot are continuously being scrutinized by the community and federal and local agencies. The results show that both environmental disamenities have a significant negative impact on the real estate market but the PCBs magnitude is greater than the chemical incinerator's. These findings are confirmed by the risk perception model, which incorporates risk perception levels of residents from the mail survey. A total of 730 usable surveys were used in the risk perception model. The conclusions are that risk perception varies with exposure to disamenities. Surveyed residents are more concerned about the risk of a possible natural disaster affecting the safety of stored chemical weapons than a possible terrorist attack on the military facility. Higher perceived risks of a natural disaster are correlated with lower house values but this price impact is reduced as distance to the incinerator is increased.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The purpose of this study is to examine the impacts of serious environmental contamination and perceived risks on residential property values in Calhoun County, Alabama. Calhoun County ranks among the worst 30% of counties in the US in terms of environmental releases and in the worst 20% in terms of cancer risk. Business magazines such as *Forbes* and *Money* rate the county seat, the city of Anniston, as one of the worst places to live in the United States. Anniston City is home to the Army Depot and Chemical Agent Disposal Facility and the former Monsanto Solutia plant, which was responsible for widespread soil contamination for long periods of time. Chemical weapons have been stored in bunkers in Anniston's outskirts for decades, and are now being incinerated there. Anniston also suffers from high soil contamination levels of polychlorinated biphenyls (PCBs) and lead, which have resulted in several lawsuits against Solutia.

In the 1920's, the chemical giant Monsanto made the city the world's biggest producer of the fire-resistant chlorine compound widely known as polychlorinated biphenyls (PCBs). Landfills now hold thousands of tons accumulated from nearly half a century of PCB wastes, and Anniston stored close to 10% of the nation's aging, leaking chemical weapons stockpile. For more than a century, the town's residents were content with their relationship with the military and the chemical industry. The city of Anniston's economic development depended on the jobs and wealth created by its chemical and soil pipe industries. Throughout the 20th century, at least 23 major industrial facilities operated in Anniston including the former Monsanto Chemical Company, foundries, soil pipes, automobile shredders, and others. The industrial operations released PCBs and lead into the environment causing serious problems associated with contamination in the southern portion of Calhoun County.

A decade later, the army arrived, bringing with it the Chemical Weapons Corps. On August 9th 2003, the U.S. Army started incinerating aging chemical weapons at the Anniston (Alabama) Army Depot to dispose of 7% of the country's stockpile of chemical nerve and blister agent in agreement with the United Nation chemical disarmament program. Although the project's mission is to prevent the future use of chemical agents in wars, the convention also set forth the terms and conditions to safely dispose of these obsolete Cold War chemical weapons. The countries that ratified the U.N. Chemical Weapons Convention agreed to dispose of their chemical weapons by April 29, 2007. If a country is unable to maintain the convention's disposal schedule, a one-time extension of up to 5 years may be granted by the U.N. However, the residents of Calhoun County view the project differently. Their main concern is the environmental risks to human health of operating a chemical demilitarization incinerator at full capacity twenty-four hours a day, seven days a week for a decade. The newly-built incinerator is only 8 miles from Anniston, and any serious incident on site could threaten the lives of thousands of residents. The risk of handling these toxic agents coupled with the possibility of an accident induces fear or concern by homeowners or buyers in proximity of the incinerator and should therefore depress the values of neighboring homes.

The real estate market is very idiosyncratic, where no two goods are alike. Such a market is called a differentiated goods market. Although some may argue that houses in a newly constructed subdivision may be perfect clones, and have nearly identical structural appearance, their geographical locations differ. A different street address is enough to differentiate these two houses one from another. The slope of the terrain and the view all differ geographically in addition to the distance to local schools, business and shopping centers and recreational facilities. Nevertheless, in reality, most houses have fairly diverse characteristics. Every house is made up of many different components, each of which may add or subtract value from the asset. Before making the decision to purchase a house, individuals evaluate the costs and benefits of an array of factors such as the size, quality, style, location, and age. More generally, these factors can be grouped in three categories: housing characteristics, neighborhood characteristics (including demographic trends), and environmental characteristics. In the end, the buyer will purchase the house with the desired characteristics that maximize his overall utility within his budget constraint.

There are several techniques that can be used to study the effects of environmental quality on property values and infer a quantitative measurement of homeowner's welfare loss or gain. The most commonly used method is the hedonic multiple regression model. The technique was popularized by Griliches (1971) and Rosen (1974). Since then, hedonic models have been widely used in environmental economics to price real estate and property. The main assumption of the hedonic model is that the price of the house is related to its structural characteristics and to its surrounding characteristics such as environmental and neighborhood quality. Estimation of hedonic housing prices can provide some information on the impact of disamenities on the welfare of neighboring residents. Most of the existing literature seems to conclude that environmental disamenities, whatever the form, generally tend to depress housing values.

The purpose of this paper is to determine the effects of both the chemical incinerator and PCB contamination site on housing values in Calhoun County. A hedonic price model, which postulates a good's price to be a function of its multiple attributes, is used to estimate the effects of environmental quality on housing values. Past hedonic studies have supported a variety of different proxy variables that explain the effects of proximity of an environmental hazard on residential housing prices. The hedonic price model developed here includes a number of physical housing characteristic variables in addition to the two main variables of concern: distance to the chemical incinerator and the PCB soil level. For a better model fit, neighborhood and environmental characteristics variables are also included in the model to control for geographical impacts that are not explained by the two aforementioned variables.

This study differs from previous works because it focuses on the newly operating chemical incinerator of Anniston explicitly licensed by the federal government's Department of Defense (DOD). The Anniston Chemical Agent Disposal Facility (ANCADF) is one of the five operational U.S. chemical incinerators constructed for the sole purpose of destroying the army's chemical weapon stockpile. After complete destruction and disposal of the byproducts, the incinerator will be disassembled and removed from the site. Another major novelty of this study is the use of actual PCB soil contamination level for each sampled house instead of a proxy variable such as the distance from each house to the Solutia plant. Cameron (2006) argues in her paper that the "two-dimensional price-distance" effect is not the same in all directions. In many cases, the level of pollution around a hazardous site is asymmetric. For instance, the movement of surface and groundwater dispensed PCBs farther in some directions than others. Houses located downstream of the Solutia facility, including some as far out as 10 miles, have been contaminated by PCBs. Thus, the use of actual measures of PCB soil levels in the hedonic model controls for directional heterogeneity in distance effects.

The results of this study should be of great value to the residents of Anniston and the surrounding area. It will offer important insights to policy makers, developers, tax assessors, and housing consumers. Most of Anniston's residents are conscious of the risks and health impacts of the PCBs in their neighborhood because the media have extensively covered the topic. Grassroots community groups[1] and federal agencies have also educated local citizens of Anniston about the adverse effects of PCBs and how to possibly prevent further exposure. However, most residents of Calhoun County are unaware of the full magnitude of the impact of the incinerator on their housing values. This model can be used by the residents to evaluate by how much their property assets have been depressed since the first public announcement of the toxicity of PCBs and the construction of the chemical agent incinerator.

[1] There are four local community groups working in Anniston: Community Against Pollution (CAP), lead by the charismatic David Baker; Families Concerned About Nerve Gas Incineration (FCANGI) formed by two Anniston residents, Brenda Linell and Jim Harmon; Serving Alabama's Future Environment (SAFE) organized at Jacksonville University by Suzanne Marshall, and the Environmental Justice Task Force (EJTF). In addition to these local groups, the nationwide Chemical Weapons Working Group (CWWG), built by Craig Williams, is also involved in local community efforts to protect the heath and safety of its citizens.

In the next section of this paper, an overview of some of the seminal research in housing valuation is provided, along with a brief review of the relevant literature. The hedonic pricing model is then developed, followed by a detailed description of the data and the variables used in the model. This section also describes the technical framework for welfare measurement. The empirical results are then presented along with tests conducted to check for multicollinearity, heteroskedasticity, and functional specification. Finally the work is summarized and the implications discussed.

1.2 Background Information about Anniston's Environmental Hazards

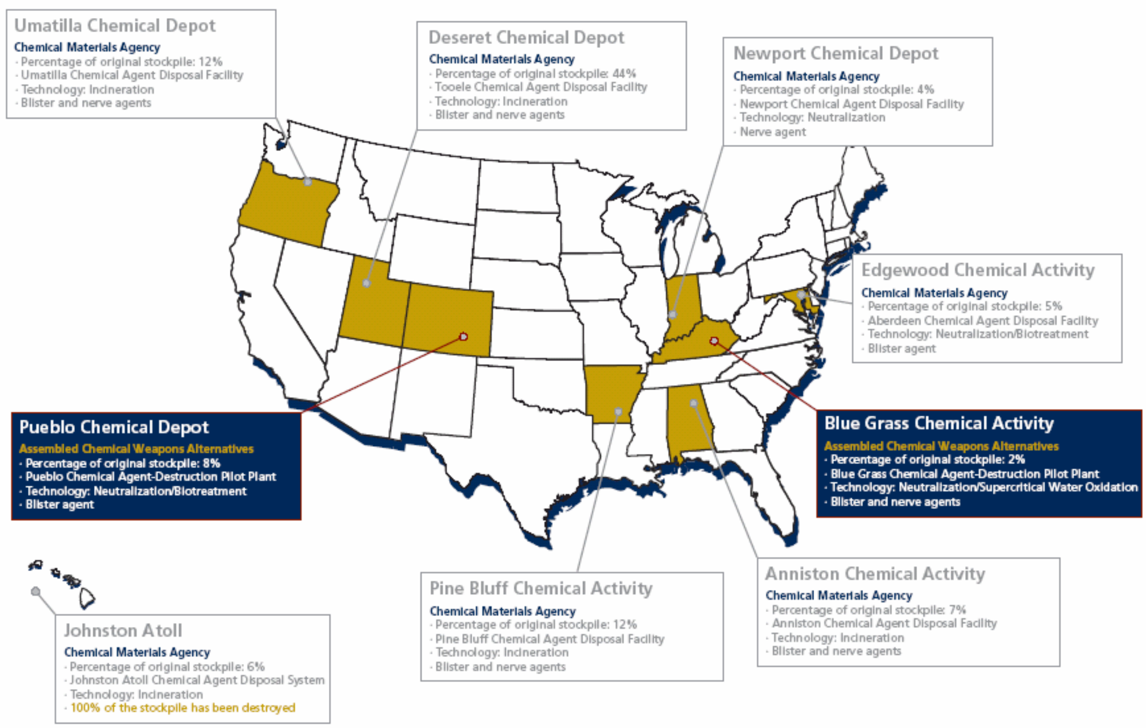
This background section briefly describes the geographic location of the Anniston Army Depot and Army's chemical weapons destruction program before describing the Solutia site and the PCBs widespread environmental contamination problem.

1.2.1 Anniston Chemical Agent Disposal Facility

Anniston Army Depot (ANAD) is an active military facility in Calhoun County, which is located in northeastern Alabama. The depot is 110 miles west of Atlanta, Georgia, and 50 miles east of Birmingham, Alabama. ANAD occupies approximately 15,200 acres 8 miles west of Anniston, Alabama (Appendix F). Several smaller towns, such as Bynum, Eastaboga, Hobson city, and Coldwater surround the facility. ANAD is bordered on the North by the Fort McClellan Military Reservation.

By the early 1960's, the rules of engagement between the two superpowers of the time, the United States and the former United Soviet Socialist Republics had changed. What had changed, of course, was the nuclear component of geopolitics. During the

Cold War years, both superpowers began mass producing and storing chemical weapons. In the midst of the Cuban missile crisis and other geopolitical tensions between the two countries, the best strategy was the principal of deterrence. If the USSR had chemical weapons or other type of mass destruction weapons, so the US had to have them too, in the name of deterrence.



Source: Assembled Chemical Weapons Alternatives (2005)

Figure 1. U.S. chemical agent stockpile distribution by storage location

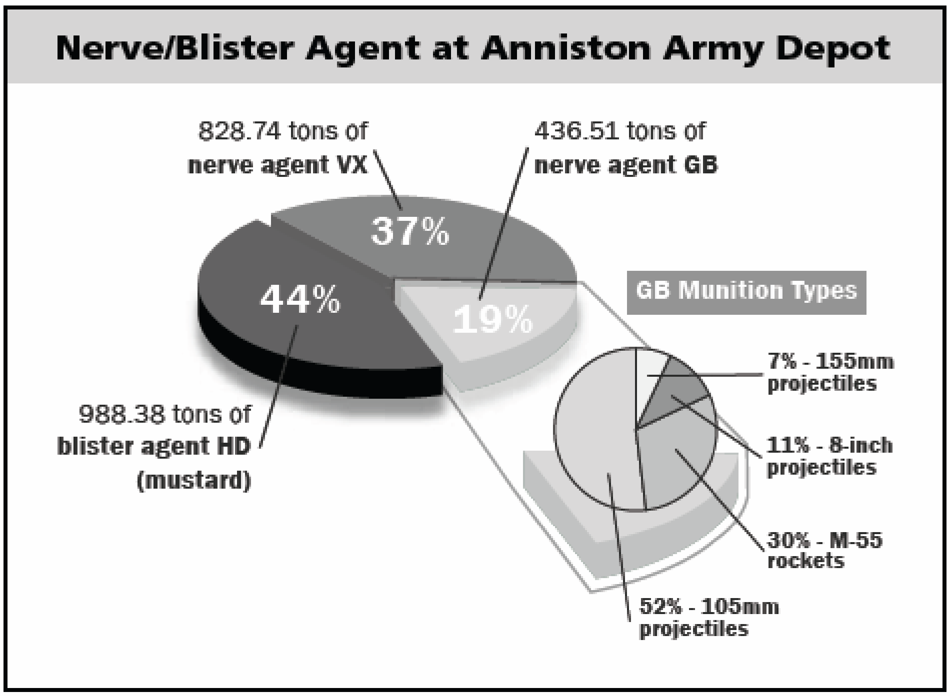
The very existence of these chemical weapons, for the most part, was kept classified and their location was held top secret. The military decided to stockpile millions of Agent-loaded rockets, land mines, bombs, and artillery shells at the Army depots in isolated areas of the country: Anniston, Alabama; Tooele, Utah; Pueblo, Colorado; Pine Bluff, Arkansas; Newport, Indiana; Richmond, Kentucky; and Edgewood, Maryland. Figure 1 identifies the locations of the chemical stockpile storage sites and the preferred method of disposal. Of these, the Tooele and Anniston sites were the major players in terms of numbers of weapons stored, with Tooele a clear number one. On the east coast, the choice was made to have the location of the depots in two of the least-educated and poorest areas of America: Lexington, Kentucky and Anniston Alabama. Among the nine chemical weapons storage sites, the Anniston Army Depot is the only one located near an urban population. In fact, 75,000 people live within nine miles from the ANAD. In 1963, the Anniston Army Depot began receiving its first secretive shipments of chemical weapons. Five years later, in 1968, the Army halted production of chemical weapons (Dennis Love, 2006).

The U.S. Army has been operating the depot at Anniston since 1941. Over the years, the depot mission has included the storage of munitions and the refurbishment of combat vehicles. The present mission of ANAD includes maintaining combat vehicles such as the M-1 Abrams tank, and storage of chemical weapons until they are completely destroyed by chemical incineration.

Chemical weapons are stored in containers of various types and sizes, and hold a variety of toxic chemical agents. Contrary to popular belief, chemical agents are not gases. Chemical agents are liquid in original form; however they deteriorate into a thick, viscous substance over time. The three stockpiled chemical agents stockpiled at the ANAD are:

- Mustard gas, termed agent HD by the Army, quickly penetrates the skin and is a potent carcinogen. Inhalation of mustard gas produces pulmonary edema.

- GB or sarin, the most volatile of the nerve agents, causes victims to experience pinpoint pupils, increased salivation, abnormal tearing of the eyes, urination, diarrhea, convulsions, respiratory collapse and death.
- VX nerve gas is twice as toxic as GB by inhalation, 10 times as toxic orally and 170 times as toxic by percutaneous administration, and has similar immediate, acute toxic effects (ACWA CW destruction program www.pmacwa.army.mil).



Source: The U.S. Army Chemical Material Agency

Figure 2. The chemical agents stored at Anniston Army Depot

The city of Anniston has always had strong ties with the military. The U.S. Army has provided jobs to many thousands of residents and a lot of local business thrived on the money spent by workers at Fort McClelland and Army base. In Calhoun County, the U.S. Army is the single largest employer with 6,800 employees on its payroll. In 1995, the Base Realignment and Closure Commission, or BRAC, decided to place Fort McClelland on the list of military bases to be closed. City officials lobbied their congressman to prolong the Fort's activities. Inevitably, the Fort military activities, the Chemical and Military Police school, National Guard training center, Woman's Army Corp Center and the Army's Combat Development Command Chemical Biological-Radiological Agency were all transferred to other Forts. Fort McClelland ceased all military activities in 1999.

And yet Fort McClellan was only part of the military presence in Anniston. The other half of the army equation there, and by far the most important half, was the Anniston Army Depot. Although Fort McClelland had a significant impact on the economic well-being of Anniston, its influence and role within Anniston and the surrounding area paled in comparison to those of the Depot. At the time when Fort McClelland was operational, it was a self-contained economy with its own housing facilities, military training schools, and many other services. ANAD was and still remains the economic engine for Calhoun County providing over 6,800 federal and contractor jobs with a total economic impact of approximately $1.8 billion. The annual payroll for the 2006 calendar year exceeds $350 millions and the total employment impact exceeds 21,000 direct and indirect jobs (The Forum, April 2007).

By the 1990s, with the decline of the Soviet Union and the end of the Cold War, the world became more aware of the widespread presence and evolving dangers of chemical weapons (CW). With increased environmental awareness and stringent regulations, the military could not dispose of its chemical weapons in the sea done previously. The Army struggled over what to do with its deteriorating chemical arsenal stockpiled at its depots. The perception of risk plays a significant role in chemical demilitarization. Studies suggest that the common justification for opposition to siting a hazardous waste facility was the perception of risk (C Bailey et al., 1992, C Zeiss, 1999). Each actor in the debate has framed the issue of risk to gain leverage in the debate over disposal options. From the beginnings of the chemical demilitarization movement, the choices available to the Army for disposal of chemical weapons were limited to chemical neutralization, incineration, or bioremediation. Further long-term storage was not seen as a viable option by the Department of Defense due to the risk of leakages and possible explosions in the aging stockpile, not to mention the increased national security threat that these toxic storage igloos could spark if attacked by terrorists. Between 1973 and 1982, the Army extensively researched neutralization, but by 1982 had made the decision to use incineration as the preferred technology for chemical weapons disposal (Suzanne Marshall, 1996). The reason given by the Army for this choice was that chemical neutralization was too complex and too costly while incineration was a familiar and, importantly, a speedy process. Chemical neutralization required much more handling of the munitions and was not the best technology to safely dismantle the fuse on missiles, mortars and other explosive devises. Given the wide range of shape and sizes of the assembled chemical weapons, the Army felt that the risks were too high to have these munitions drained from their lethal chemical substances and disassembled for chemical neutralization, as the risk of accident was deemed too high. Because the particulars on the location and composition of the chemical weapons stockpiles were classified information at this point of time, this decision in favor of incineration was made without input from the citizens living on the vicinity of the stockpiles.

In the early 80's the US government viewed incineration as the preferred and least risky technology for disposing its chemical weapons. In 1988 the Army made the decision to incinerate on-site, citing safety hazards involved with transportation of chemicals to alternative facilities. Based on this decision, the Army made plans to build a multi-billion dollar chemical weapons incinerator at the Anniston depot. The Anniston facility incinerates the weapons using robotic equipment to disassemble the weapons so that each component can be treated in a separate incinerator. Specifically, the chemical agent is drained from the weapon and burned in a liquid incinerator, while the weapon's explosive components are destroyed in a special deactivation furnace.

Construction of the chemical weapons disposal facility in Anniston began in 1997 and was completed in 2001. The Anniston Chemical Agent Disposal Facility (ANCADF) is a state-of-the-art incineration facility designed to dispose of the chemical weapons stockpile stashed at the Anniston Army Depot safely and efficiently. The facility first started disposing GB nerve agents on August 9, 2003. The first GB munitions to be destroyed were the M-55 rockets, as they pose the greatest threat to the public in continued storage. After processing the 437 tons of GB agent, the ANCADF will be reconfigured for incineration of nerve agent VX munitions and finally blister agent HD. Disposal operations are expected to last approximately nine years, from 2003 until 2012, barring any unforeseen delays. Once the Army has completed the destruction of Anniston's stockpile, the disposal facility will be dismantled and decommissioned, and the Army depot will continue supporting its other mission areas.

1.2.2 The Solutia Plant (Monsanto Company)

Starting in the late 1920s the Monsanto Company manufactured PCBs in its plant in Anniston, ceasing production after they were banned in the early 1970s. The production of PCBs was highly profitable for Monsanto for the following two reasons. First, Monsanto was the sole United States producer of PCBs. All PCBs manufactured in the United States were manufactured at two plants; one in the western part of Anniston, Alabama and the other in Sauget, Illinois. Besides the benefits of having the exclusive marketing rights on Aroclors, U.S. trade name for PCBs, Monsanto profits soared with the high demand of PCBs.

PCBs were favored by the booming electrical industry of the 20th century because they were non-flammable and could conduct heat without conducting electricity. Therefore, they were widely used as insulation in electrical transformers and capacitors. PCBs also found other commercial usages as pesticides, hydraulic fluid, paint additive, newsprint, carbonless copy paper, coils in deep fat fryers. Besides keeping American households safe from electrical fires and shortages, scientists and citizens were becoming more aware of the adverse effects of PCBs on human health and the environment. PCBs remain toxic in low concentrations and do not readily break down in the environment. They tend to settle in the beds of creeks, streams and rivers and bioaccumulate in the fatty tissue of animals and humans.

Because of the longevity of PCBs and their hazardous effects on humans and the environment, Monsanto stopped producing PCBs in Anniston in 1971, eight years before the United States government officially banned their production. Numerous tests and empirical evidence show that PCBs cause cancer, liver disease, diabetes, adverse skin conditions and other maladies in humans, as well as diseases and death of several species of animals.

During the forty years of PCB production, Monsanto engaged in substandard landfilling and improper disposal of byproducts. Millions of pounds of PCBs were released from the plant into the environment through the disposal of PCB liquids, sludge, and other wastes into unlined and uncapped landfills. Leakage of PCBs from the landfills migrated through a large area of Anniston, causing soil contamination and exposing a large number of citizens to risk of PCB related cancers and other serious consequences.

1.3 Compounds of Concern

The U.S. EPA has determined that there are two primary chemical compounds of concern in the Anniston area warranting time critical removal action because of risks to the environment and public health. Large areas in Anniston and its environs are contaminated at levels of concern with both lead and PCBs, while other relatively limited areas are contaminated with only lead or only PCBs at levels of concern. The EPA initiates remedial actions for sites that have elevated concentrations beyond 400 parts per million (ppm) and 1 ppm of lead and PCB respectively. Therefore the PCB and lead contamination zones, while distinct, do overlap geographically in areas where both lead and PCB pollution is present. This study focuses on the evaluation of PCB contamination impacts throughout the city of Anniston. However lead is a compound of concern that needs to be accounted for in the analysis because it was part of Monsanto's PCBs manufacturing process at the Anniston plant. From the beginning in 1928 until the early 1960s, Monsanto manufactured PCBs using the lead pot process (E. Mather, 1950).

The lead pot process consisted of large vats filled with molten lead, which emitted over the years unprecedented amounts of lead vapors into the atmosphere. Irrefutably, the lead pot process was a major source of fugitive lead air emissions but it also generated tons of lead waste materials when the pots had to be emptied and cleaned. These compounds are ubiquitous pollutants in the Anniston environment. Both of these chemical compounds have different properties and adverse effects on human health. One of them is classified as a persistent organic pollutant (POP) and the other falls under the heavy metal classification. A short description of the considered pollutants properties is given below.

Lead (Pb)

The Anniston lead site is located primarily in Anniston and Hobson city. Specifically, EPA became aware of high soil lead concentrations in neighborhoods in western Anniston in 1999-2000 when it was investigating the extent of the Anniston PCB Site. The lead contamination was caused by at least 20 current and former industrial facilities, including the former Monsanto PCB plant. These industrial facilities consisted mostly of foundries, but also included to a lesser degree munitions manufacturers and steel manufacturers (Appendix B). Sampling results show that at least 342 residential properties contained soil lead concentrations above EPA's accepted level of 400 parts per million (ppm). Until now, EPA has cleaned up at least 133 of the 342 properties with elevated lead levels and is making steady progress in decontaminating the remaining 209 residential properties.

Furthermore, it appears likely that the available lead sampling has not fully described the nature and extent of lead contamination in Anniston. Other sources of lead emission sites and other routes of exposures, in addition to air emissions, may exist. In fact, based on Anniston's heavy industrial history, a dozen of current and former industries are known to have produced lead byproducts, such as foundries, lead pipe manufacturing facilities, automobile shredders and smelters. In addition to the aforementioned sources of lead contamination, the 1999 Health Consultation drafted by the ADPH and ATSDR, pointed out a rather unique source of emission of lead. This additional source of lead contamination emanated from sand used in foundries to cast metal parts. Subsequently, the used foundry sand[2] was sold as filling materials to local business in the community. A certain proportion of this contaminated sand was transported off-site and ended up in residents' backwards and in school playgrounds, thus exposing residents and children to the effects of lead poisoning. In response to the complexity and liabilities issues at risk with lead contamination, further studies are currently in progress to shed light on this hot topic. Needless to say, these dozen or more industries (see Appendix B for a list of these companies) face several multi-million dollar lawsuits and possible remediation actions similar to the Monsanto/Solutia case. However, the lead contamination case is not as simple and straightforward as the PCB contamination case because there are several actors involved with lead and unlike PCBs and its numerous isomers, lead is a heavy metal that is much harder to trace back to its production source.

[2] The term "foundry sand" refers to sand or similar materials generated in the foundry manufacturing process. Sand is used to cast metal parts and is a byproduct that was revaluated as a filling material.

As previously mentioned, EPA and Tetra Tech EMI have only been testing for lead in residential and commercial soil samples since 2000. For each composite soil sample, EMI scientific testing laboratory screened for heavy metals (Lead, Mercury, Copper etc), persistent organic pollutants (PCBs, DDT, Dioxins etc.) and other hazardous chemical substances. Therefore, there is a high probability that if a property has been tested for high levels of PCBs that it most likely will test positive for above average lead levels. This high correlation between PCB and lead levels makes it very hard to include both variables into the same hedonic model. To avoid inducing extreme collinearity, the lead level was not included in the final hedonic model. However, the PCB variable accounts for some degree of the lead level and other hazardous substances that were screened for in the soil sampling process. In essence, it would be worthwhile replicating this study using the lead level instead of those of PCBs to see the economical and welfare impact of lead pollution on housing values. This extends beyond the framework of this thesis and will not be treated hereafter.

Polychlorinated Biphenyls (PCBs)

According to the International Agency of Research on Cancer (IARC) and the National Cancer Institute (NCI), PCBs are classified as probable human carcinogens (IARC, 1987, NCI 1978). As with all carcinogenic compounds, PCBs directly affect the health status of those who are exposed or intake it through contaminated water and or food. Moreover, PCBs can affect the human reproductive system resulting in serious birth malformations.

PCBs are resistant to external effects such as high temperatures, and they also have a small reactive capability. Another important characteristic of PCBs is their high lipophily which causes PCBs to accumulate in fat tissues of man, animals and fish. In addition, these compounds are easily absorbed by soil- particles and settle at the bottom of streams and rivers soil. Numerous measurements demonstrate that they are omnipresent in the Anniston environment and in the blood system of many city residents.

1.4 Remedial Action

To facilitate management and control of contaminated soils near the Anniston plant, Monsanto conducted voluntary property purchase programs to acquire nearby residential properties in the mid 1990s. Many residents in West Anniston have accepted these cash settlements from Monsanto Company and have since relocated elsewhere. Hundreds of both residential and commercial properties surrounding the former Monsanto plant have been torn down and fenced off. These vacant parcels serve as a buffer zone around the chemical plant and will remain idle until a long term solution can be found to the PCB and lead contamination problem.

Those who chose to stay in their homes and have high concentrations of pollutants in their yards, have been offered help to cleanup their properties from lead and PCBs. For remedial action, EPA has determined that properties with PCB and/or lead concentrations greater or equal to respectively 1ppm and 400 ppm, to be selected for cleanup. Yard cleanup activities entail removal of the contaminated topsoil, disposal of the excavated soil at a solid waste landfill, and backfilling of excavations with at least one foot of clean soil. The end result of the cleanup process is to remediate properties identified by EPA and to prevent current residents from further exposure to PCB and lead poisoning.

Other corrective actions were taken by Monsanto and Solutia from 1995 through 1998. In 1997 Solutia completed the installation of a cap and cover system on two landfills, the west and south-end landfills (see map of Solutia Site in Appendix G), as well as the construction of a storm water detention pond to control the migration of PCBs runoffs from the plant area. Solutia regularly reports the results of surface water samples to the Alabama Department of Environmental Management (ADEM) in order to monitor the ongoing effectiveness of these corrective measures.

1.5 Problem Definition

The objective of this thesis is twofold. The first objective is to determine the impact of proximity to the Anniston Chemical Weapon Incinerator and high PCB levels on property values. The second objective will be to examine if risk perceptions of homeowners in Calhoun County are systematically related to proximity to the incinerator.

Chapter 2 presents the literature review related to the topics of hedonic pricing models. Chapter 3 describes the methodology used in this thesis. Data collection, the hedonic pricing model and the related research will be reviewed, and the development of the models is discussed. Finally the specific models used in this research are presented.

Chapter 4 is a detailed description of the approval, setup and implementation of the mass mail survey. This chapter discusses data collection analysis and procedures for the property value data set. This includes a review of the survey instrument's contents and descriptive findings whereas chapter 5 presents the results and analysis of the study.

The last chapter (chapter 6) summarizes the problem statement, conceptual models and analysis, develop conclusions about the study's finding and make suggestions for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 Hedonic Price Model

Residential homes are made up of a large number of physical and locational attributes that can either add to or subtract from its value. In Nelson, Genereux and Genereux's (1992) study, an empirical model was used to estimate the price effect of landfills on nearby homes. Using ordinary least squares regression, they concluded that homes farther away from the landfill site were valued at significantly higher prices than those neighboring the point source pollution site. In Boyle and Taylor's (2001) study, accuracy of the estimated willingness to pay for environmental amenities drawn from tax-assessor data versus survey data was compared. Both methods for collecting data provided statistically coherent results highlighting the fact that neither one nor the other dataset contained substantial measurement errors. In addition, they estimated the price effect of point-source pollution on nearby houses. Both air and noise pollution dissipate the further a house is located from the emitting source. Thus home-owners who reside in cleaner and quieter neighborhoods pay a price premium to enjoy higher standards of environmental quality.

The hedonic price method is derived from the theory of value developed by Lancaster (1966) and extended and formalized by Griliches (1971) and Rosen (1974).

All of the models discussed in these papers assume that the price of a house is a function of the characteristics it contains. Moreover, the theory of hedonic prices assumes that the utility derived by home buyers is a function of: a vector of structural characteristics of the house, a vector of characteristics of the neighborhood where the home is located, and a vector of specific local environmental amenities or disamenities.

The results from the wide range of studies in the literature indicate that changes in any of the previously mentioned characteristics affect housing unit values in highly statistically and economically significant ways. For example, simple distance to the incinerator variables proves to be an effective price predictor. Close proximity to a chemical incinerator depresses housing values, often substantially.

Home buyers often care about subtle neighborhood qualities, public services and proximity to relatives and other "goods" a location and its environment offer. Rather than attempting to elucidate all determinants of home valuation, this paper focuses primarily on the environmental impact of the chemical incinerator of Anniston on the price of homes, and to a lesser degree on the impacts of PCB contamination and toxic air releases.

The goal of most hedonic estimation in environmental economics is to obtain a welfare measurement or the marginal willingness to pay associated with changes in the quantities of some environmental characteristics (e.g. siting of an incinerator). However, the techniques that must be used differ greatly depending on the type of environmental change, the transaction costs in the housing market, and the time period considered. The environmental change might affect only a small number of properties relative to the size of the market. This is the case of a localized externality such as PCBs (RB Palmquist, 1992), and the hedonic price function is not expected to change. On the other hand, the environmental change may affect a large part of the market (such as the incinerator), resulting in a change in the hedonic price function.

Localized externalities

The owners of the houses where environmental changes occur will experience capital gains or losses representing the marginal amount the owners would be willing to pay or accept for the change. The capital gains or losses can be forecast from the hedonic price model. This is the simplest case of a hedonic welfare measure.

Timing of Environmental Impacts

When an environmental change takes place, an important issue is at what time the change becomes reflected in the property values. Changes in property values also depend on information and expectations of agents in the market, which are affected by news announcements, for example. Property values provide information on residents' expectations, often reacting before the environmental change. In most cases, property values will exhibit weakness once public hearings have been held in the community. Finally, a measurable property value impact requires that consumers be aware of the environmental conditions. Time-sensitive hedonic studies can be used to capture variations in environmental conditions in order to examine any possible changes in knowledge and perceived risk.

There have been a number of studies that considered the timing of property value impacts. Many, but not all, have studied hazardous waste sites and related operations.

One example is Kohlhase (1991). She studied toxic waste dumps in the Houston area to see when residents became aware of problems and to examine their significant effects on property values. Her findings indicated that property values were not affected when the sites were operating but not well publicized. It was only after a site was placed on the National Priorities List of Superfund that significant negative effects on property values were found. A tentative encouraging finding was that after a toxic site was cleaned up, there seemed to be no residual effect.

A similar study is Kiel and McClain (1995) who studied the effects of the construction of a hazardous waste incinerator. They considered four stages associated with the incinerator's operating life-time, starting with pre-rumor and going through rumor, construction, and finally ongoing operation. They ran separate hedonics for each stage and found there was no effect in the first two stages. During construction there was a significant negative effect on property values that became larger when the incinerator started operation. However, after it had been operating a while, the effect, while still negative and significant, returned to the lower level it had had during construction. Presumably, this occurred as the residents gained more information about the operation.

Dale, Murdoch, Thayer, and Waddell (1999) performed a similar study of the impacts in different time periods from a lead smelter that was eventually closed and the site cleaned up. They find that, while there was a significant negative effect on property values while the smelter was operating and immediately after it closed, once the site was cleaned up, property values rebounded. The stigma of the smelter disappeared.

Hite et al. (2001) use a cross-section of house sales in areas where there are landfills in various stages of their operational lives. The results suggest property value impacts decrease after a landfill is closed, but do not dissipate completely.

2.2 Environmental Risks

Considerable research has been done on public perceptions of the risk associated with the toxic and hazardous contaminated sites (T Gayer et al., 2002, 2000, GH McClelland et al., 1990, JJ McCluskey et al., 2001) . McClelland et al. (1990) estimated the effect of health risk beliefs on property values in the Los Angeles area. They found that health risks beliefs had a substantial negative correlation with property values and risk beliefs decreased when moving away from hazardous waste sites. Gayer et al. (2000) examined the effect of cancer risk perceptions from Superfund sites on house prices in the Grand Rapids, Michigan before and after the Environmental Protection Agency (EPA) released its assessment of site risks. Total cancer risk is the sum of cancer risk from soil and groundwater contamination at each of the Superfund sites. They found that people are willing to pay more for houses exposed to lower levels of Superfund cancer risk and residents' willingness to pay to reduce risks decreased after the assessment was released. McClusky et al. (2001) studied the impact of perceived risks on property value, where perceived risk was assumed to be a function of lagged perceived risk and media coverage of the hazardous waste sites in Dallas County, Texas. The authors found that perceived risk had a negative relationship with house prices, and media coverage increased perceived risk.

Other studies have related these risk perceptions to public views towards disposal strategies. For example, do the residents of Anniston concerned with the risk of storing chemical weapons prefer a certain type of deactivation strategy?

CHAPTER 3

MODELLING FRAMEWORK

3.1 The Hedonic Model

One of the simplest methods to estimate the price of homes is the hedonic price model, in which sales price is modeled as a function of a good's multiple attributes (Z Griliches, 1971). Generally, the hedonic price model includes a series of variables, such as house size, lot size and number of rooms along with dummy variables to account for specific positive and negative housing characteristics. This allows us to use the model to predict the individual influence of any given housing characteristic, holding constant the influence of all remaining factors.

In the literature on housing appraisal, two alternative functional forms are predominantly used in the hedonic price models: the linear and the log-linear models. The linear model implies constant partial effects between the house's characteristics and its selling price, while the log-linear model allows for non-linear price effects. If the model is specified in log-linear functional form, then the regression coefficients of the continuous variables indicate the proportional percentage impact on housing prices and the regression coefficients of the dummy variables indicate the percentage impact of that characteristic on the price of the house. Kohlhase (1991) and Reichert (1997) both used a log-linear functional form for their hedonic price model to account for the non-linear distance relationship when studying landfill impacts. They subdivided their sample into concentric circles and tested whether or not there were any significant differences in the coefficient estimates between the rings. Both studies showed that the impact on real estate value is not directly proportional to the distance to the landfill, so an assumption of constant marginal effect (as in the linear mode) is rejected.

The advantage of the hedonic multiple regression model is that it can easily be used to estimate the effects of variations in housing, neighborhood and environmental factors on residential property values. This is the method used throughout this paper and moreover, the resulting coefficient estimates can be directly interpreted as the proportional contributions of these attributes.

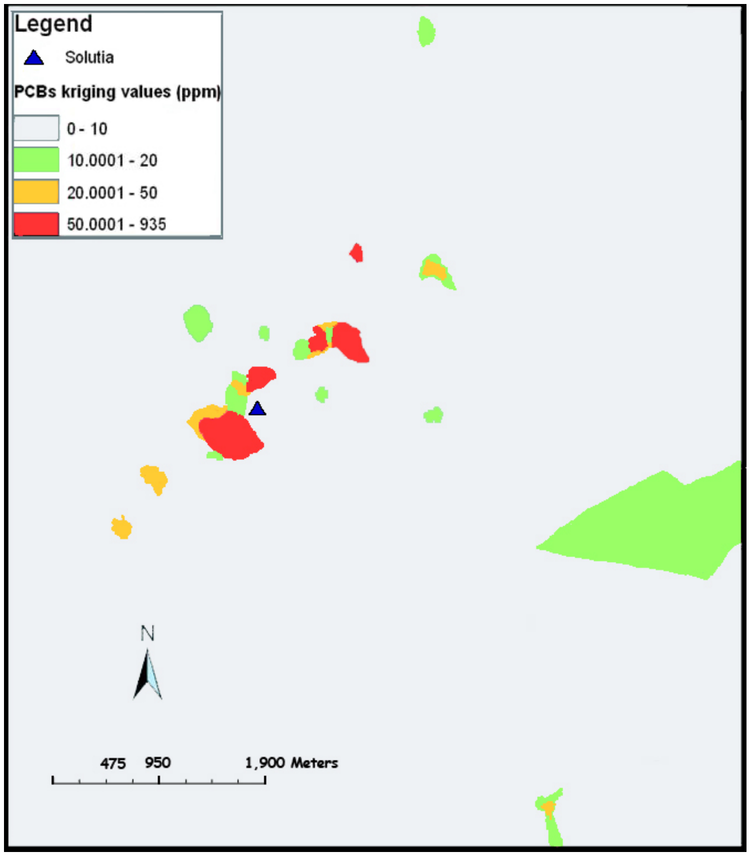
3.2 Theoretical Specification

The hedonic price function used in this study was estimated using the conventional practice of postulating the independent variable, the log of housing price adjusted for inflation (ln Price), as a function of a vector of structural variables (Structural), a vector of neighborhood variables (Neighborhood), and a vector of environmental variables (Environmental). These three variable vectors are the basis of the theoretical model presented below in equation [1]. The empirical model also controls for fixed time effects by incorporating dummy variables for the years in which groundbreaking news were publicly announced (1971, 1993, 1996 and 1999). Similarly, the model also controls for continuous time effects such as inflation. A time variable (Period) was included whose values runs from 1 to 684, reflecting the 684 months between January 1948 and December 2004. The semi logarithmic form of the hedonic price function is expressed as

$$\textbf{Ln } \textbf{\textit{Price}} = \boldsymbol{\alpha} + \boldsymbol{\beta}\textbf{\textit{Structural}} + \boldsymbol{\gamma}\textbf{\textit{Neighboorhood}} + \boldsymbol{\rho}\textbf{\textit{Environmental}} + \boldsymbol{\tau}\textbf{\textit{Period}} + \boldsymbol{\varepsilon} \qquad \textbf{[1]}$$

This general hedonic price function can be expanded upon by including two other variables of interest for this paper. These additional variables will help test the hypotheses stated in the introduction chapter. Amongst the environmental variables, the two worth highlighting in this section are the distance variable to the ANCDF site (Incinerator) and the objective measure of PCB soil contamination variable (PCB30m1000). As mentioned earlier, quantitative measures of toxic chemicals per residence is preferred to proxy variables such as straight-line distance from the house to the site of pollution. The only caveat in using objective measures of PCB levels in residential properties yards is that it restricts the variable to only those properties that have been sampled by U.S. EPA officials. Thus, a neighboring property to one that has not been sampled might have been tested for presence of elevated levels of PCBs and other toxic chemicals. To capture the effects of hazardous chemicals on all property values, regardless of whether they were sampled or not, the spatial kriging interpolation technique was used to interpolate PCB levels across all residential properties in the county. The PCB kriged values were constructed by weighing the closest thirty PCB soil sample results within a one kilometer radius from each geographical point. The geospatial kriging tool creates isolevel surfaces for different concentration levels of PCB (see figure 3). Each transacted house was then assigned a level of PCB ranging from non detectable levels (0 ppm) to 99.167 ppm. Moreover, 783 properties had levels greater than zero and only 260 had levels above EPA's health based action level of 1 ppm.

Figure 3. Map of PCB hot-spots in West Anniston



Source: ArcMap® using PCB levels from EPA (2006)

Additionally, the empirical model also includes measures of overall levels of the environmental conditions of the neighborhood. These measures are captured by the distance variable to the environmental disamenities (Solutia plant and ANCADF), and distance to the nearest waterway (Stream). Most importantly, residential property values are also a function of the soil contamination level of both lead and PCB.

$$\text{Ln } \textit{Price} = \alpha + \beta \textit{Structural} + \gamma \textit{Neighboorhood} + \kappa \textit{Environmental} + \tau \textit{Period} + \lambda \textit{Incinerator} + \nu \textit{PCB} + \rho \textit{1971} + \upsilon \textit{1993} + \mu \textit{1996} + \omega \textit{1999} + \varepsilon \qquad [2]$$

Although there are many potential housing characteristics that can be included in the hedonic pricing model, economists tend to include more or less the same explanatory variables in their studies. The empirical model used for this study is similar to the model developed by Smolen et al. (1992). Smolen, Moore and Conway include various independent variables to determine the effects of landfills containing hazardous waste on local housing values. After testing for goodness-of-fit of variables, some variables are best if transformed to linear or log distributions. Only three variables: acres, building age, and distance to the incinerator are log distributed. The remaining variables included in the regression are linearly distributed. See table 1 for a description of the variables used and their expected sign. The hedonic price function is specified below in equation [3].

$$\mathbf{Log(REAL\_PRICE)}_i = \alpha_0 + \alpha_1\mathbf{*URBAN}_i + \alpha_2\mathbf{*\ UNDER\_TRUE}_i + \alpha_3\mathbf{*UNDER\_TRUE*PCB}_i + \alpha_4\mathbf{*log(ACRES)}_i + \alpha_5\mathbf{*SIZE}_i + \alpha_6\mathbf{*\ ROOMS}_i + \alpha_7\mathbf{*FULLBATH}_i + \alpha_8\mathbf{*HALFBATH}_i + \alpha_9\mathbf{*GARAGE}_i + \alpha_{10}\mathbf{*FIREPLACE}_i + \alpha_{11}\mathbf{*POOL}_i + \alpha_{12}\mathbf{*STORIES}_i + \alpha_{13}\mathbf{*UTILITY\_BLDG}_i + \alpha_{14}\mathbf{*TRANSACTIONS}_i + \alpha_{15}\mathbf{*log(BLDGAGE)}_i + \alpha_{16}\mathbf{*PCB30M100}_i + \alpha_{17}\mathbf{*log(INCINERATOR)}_i + \alpha_{18}\mathbf{*UNEMPLOYED}_i + \alpha_{19}\mathbf{*WHITE}_i + \alpha_{20}\mathbf{*\ UNSKILLEDLABOR}_i + \alpha_{21}\mathbf{*AIR\_RELEASE}_i + \alpha_{22}\mathbf{*CRIMERATE}_i + \alpha_{23}\mathbf{*1971}_i + \alpha_{24}\mathbf{*1993}_i + \alpha_{25}\mathbf{*1996}_i + \alpha_{26}\mathbf{*1999}_i + \alpha_{27}\mathbf{*PERIOD}_i + \varepsilon_i \qquad \mathbf{[3]}$$

Most housing characteristics are expected to have a positive impact on the selling price. The variable ln(AGE) is expected to have a negative relation with the price of the house. In other words, newer houses have a higher market value than older ones. This in part is due to increased maintenance costs that the owner has to bear to keep the housing structure in good condition as well as to changing tastes of buyers with respect to property characteristics. Environmental disamenities take away value from the house, thus factors such as air pollution (AIR RELEASE), PCB contamination level (PCB30M1000), and distance to the incinerator (INCINERATOR) should have a negative coefficient. The time variable (PERIOD) is presumed to be positive, highlighting the appreciation of the housing market over the 56 years time period.

Table 1 Definition and expected sign of variables used in the empirical model

Variable Name		Definition	Sign
Continuous Variables			
PRICE	=	Amount of transaction in 2007 dollars	n.a.
ACRES	=	Area of the parcel on which the house sits on	(+)
SIZE	=	Building's adjusted square foot size	(+)
ROOMS	=	Count of rooms	(+)
FULL BATH	=	Count of full bathrooms	(+)
HALF BATH	=	Count of partial or half bathrooms	(+)
STORIES	=	House-level descriptor – Number of stories	(+)
UTILITY BLDG	=	Number of utility buildings or sheds	(+)
TRANSACTIONS	=	Numbers of transactions	(–)
BUILDING AGE	=	Age of the house, in years. Base year 2007.	(–)
PCB30M1000	=	Kriged value of PCBs soil level	(–)
INCINERATOR	=	The distance in kilometers from the ANCADF	(+)
UNEMPLOYED	=	Unemployment level at the CBG[3]	(–)
WHITE	=	Number of Caucasians in the CBG	(+)
UNSKILLED LABOR	=	Rate of the labor force that work in production	(–)
AIR RELEASE	=	All air releases in pounds by CBG	(–)
CRIME RATE	=	Crime rate level per capita at the CBG level	(–)
PERIOD	=	Sales date period of the house	(+)
Dummy Variables			
URBAN	=	1 for properties in urban area, 0 otherwise	(+)
UNDER_TRUE	=	1 for house sold under true value, 0 otherwise	(+)
GARAGE	=	1 for house with a garage, 0 otherwise	(+)
FIREPLACE	=	1 for house with a fireplace, 0 otherwise	(+)
POOL	=	1 for house with a in ground pool, 0 otherwise	(+)
1971	=	1 if house sold after 1971, 0 otherwise	(–)
1993	=	1 if house sold after 1993, 0 otherwise	(–)
1996	=	1 if house sold after 1996, 0 otherwise	(–)
1999	=	1 if house sold after 1999, 0 otherwise	(–)

[3] A Census block group (CBG) is a subdivision of a census tract. A block is the smallest geographic unit for which the Census Bureau tabulates 100-percent data. Many blocks correspond to individual city blocks bounded by streets, but blocks – especially in rural areas – may include many square miles and may have boundaries that are not streets. Block groups generally contain between 600 and 3,000 people and never cross the boundaries of states or counties.

CHAPTER 4

DATA

This section presents and discusses the four primary data sources that were combined in order to address the main hypothesis of this research study. First, the sales prices and housing attributes data are presented followed by a brief description of the census data used. Then, the multiple geographic information system data layers (rivers, flood zones, schools, political boundaries and permit compliance system) are reviewed and discussed. Finally, the self administered mail survey methods are presented and the respondent's data is explained. The data are described in greater detail in the following sub-sections, with emphasis given to discussion of the direct mail survey.

4.1 Sales Prices and Housing Characteristics Dataset

The Calhoun County sales price data was purchased from the Calhoun County Mapping Department and Tax Revenue Commission Service on June 14, 2005. The data contained both sales prices along with the property attributes and the corresponding shape files of all residential parcels in the county. The sales data for each house and its characteristics were recorded in electronic format. Additionally, the Calhoun Mapping Department updates these records on a monthly basis and this information is publicly available online via the county's tax assessor's website (www.emapplus.com). The availability of updated information was useful to complete any missing variables in the sales price dataset. The Calhoun County data file contained detailed sales history of all 64,974 single family housing units.

This historic dataset of residential properties in Calhoun County forms the basis for all other data collected. This comprehensive geodatabase contains for most residential properties information on sales dates and transaction price as well as structural and other property characteristics. The amount of information available is considerable. For each property, there are detailed data for the following characteristics: number of bedrooms, number of bathrooms, number of stories, building age, municipal district, tax district, subdivision lot, availability of garage space, utility sheds, deck, carport, swimming pool, and barns among others. The wide range of the characteristics collected is one of the main advantages of this data set, making it possible to estimate hedonic equations.

However, before the housing characteristic data could be used, intensive filtering and cross-checking of raw information was necessary. For the purpose of the hedonic model, houses with either no recorded sales price and or no detailed housing characteristic were deleted from the initial database. After thorough cleaning of the database, only 9,655 housing transactions records, including repeat sales, were retained. Excluding the repeat sales, only 4, 669 unique single family residences are accounted for in our final housing dataset.

4.2 Census Data

In addition to using the housing characteristics from the auditor's data, census block group data from the U.S. Census Bureau was used to generate characteristics for each neighborhood included in the scope of the study. Among the numerous socio-economic factors available from the Census data, only a few were selected for this paper: average income and education per household owner, unemployment rate, percentage of whites and population density. Census data were merged with house sales so that each house transaction is linked to the demographic variables of the block group in which it is located.

Education and crime data came respectively from Alabama's Department of Education and the Federal Bureau of Investigation (FBI). Finally, measurement of the levels of air, water and land pollution was obtained for 2000 and 2003 through the U.S. EPA's Toxic Release Inventory (TRI).

4.3 GIS Data

A Geographic Information System (GIS) analysis determined the longitude and latitude coordinates of the houses and computed the distances of each house to the two major environmental disamenities sites (ANCADF and Solutia) and to the nearest waterway. Using GIS technology, each transacted house was linked to the demographic data for its census tract, city, and school district.

Information on distance to the ANCADF was calculated using ARC GIS®. Calhoun County is set up as a grid of X and Y coordinates. Coordinates are then assigned to each house and the ANCADF site using Geographical Information System

(GIS). The GIS database is also used to link each house to its census block group and with EPA's 2000 and 2003 Toxic Release Inventory (TRI). The U.S. EPA compiles the TRI data each year allowing communities to monitor the amount of pollution generated by each industrial site. The TRI is a database that includes detailed information on the releases of more than 650 toxic substances, which is available to the public via the Internet (www.epa.gov/tri or www.rtk.net). The program measures emission levels for all three pollution pathways: air, water and land. The total release variable is a rough indicator of environmental progress over time. The straight-line distance from the housing unit to the ANCADF and the measure of air quality are significant determinants of house prices (DR Haurin et al., 1996, VK Smith et al., 1995).

In February 2000, EPA established a Community Relations Center[4] in downtown Anniston. Shortly after, EPA conducted a massive site investigation in coordination with ADEM, the Alabama Department of Public Health, Tetra Tech EM, Inc., and the Agency for Toxic Substances Disease Control Registry (ATSDR). During the early site investigation, EPA took over 2,500 samples from over 800 locations, both residential and commercial. As of the end of the calendar year 2005, approximately 2,000 residential properties have been sampled and tested for PCB contamination (EPA CERCLA Section 122). Among those samples properties, 160 have been cleaned up by removing the contaminated top soils and at least another 100 residential properties have been identified for remediation work. EPA is currently cleaning-up at a pace of 20 yards per month.

The EPA database obtained for this study comprises sampling results for both PCBs and lead. The results of this data clearly indicated that the Anniston valley, the

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[4] The PCB Site office is located at 1514 W. 10th St. and the Lead Site office is located at 902 Noble Street.

waterways leaving the valley, and areas downstream have been contaminated with PCBs above those typically found in other parts of the county. The data generally indicates that throughout these areas relatively uniform levels of PCB contamination exist. For example, the vast majority of the samples indicate levels of PCBs between non-detect and 10 part per million (ppm). However, a small percentage of samples do indicate specific locations with higher levels of PCBs.

Table 2 Types of variables and their source

Variable Name	Source
Housing Characteristics	
REAL PRICE	Calhoun County Property Tax System
UNDER TRUE	Calhoun County Property Tax System
ACRES	Calhoun County Property Tax System
ADJUSTED SQUARE FOOTAGE	Calhoun County Property Tax System
ROOMS	Calhoun County Property Tax System
FULL BATH	Calhoun County Property Tax System
HALF BATH	Calhoun County Property Tax System
GARAGE	Calhoun County Property Tax System
FIREPLACE	Calhoun County Property Tax System
POOL	Calhoun County Property Tax System
STORIES	Calhoun County Property Tax System
UTILITY BLDG	Calhoun County Property Tax System
NO OF TRANSACTIONS	Calhoun County Property Tax System
BUILDING AGE	Calhoun County Property Tax System
DV 1971	Calhoun County Property Tax System
DV 1993	Calhoun County Property Tax System
DV 1996	Calhoun County Property Tax System
DV 1999	Calhoun County Property Tax System
DATE OF SALE	Calhoun County Property Tax System
Neighborhood Characteristics	
COLLEGE DEGREE	Census Bureau data
WHITE	Census Bureau data
UNSKILLED LABOR	Census Bureau data
URBAN POPULATION	Census Bureau data
CRIME RATE	F.B.I. Unified Crime Reports
CRIME PER CAPITA	F.B.I. Unified Crime Reports
Environmental Characteristics	
PCB30M1000	U.S. EPA Anniston PCB Project Office
DISTANCE TO INCINIRATOR	Arc GIS®
AIR RELEASE	Toxic Release Inventory

A summary of the types of variables used in the hedonic price model along with the source of the variables is presented in table 2 above.

4.4 The Calhoun County Risk Survey

The Calhoun County Risk Survey (Appendix D) was mailed to a representative sample of 3,500 homeowners to gather data on their levels of information and attitudes about environmental risks. The primary objective of the Calhoun County Risk Survey[5] was to establish a database of homeowners' perceived environmental risks in a representative sample of residents that recently purchased a home in Calhoun County. Data obtained from the risk perception survey allows us to test the second hypothesis of this paper: does risk perception vary with exposure to disamenities?

A representative sample of 3,500 residents was randomly selected from among those who have purchased a home in Calhoun County between 1993 and 2005. The primary objective of the Calhoun County Risk Survey was to establish a database of homeowners' perceived environmental risks in a representative sample of residents that purchased a home in Calhoun County from 1993 to 2005. The surveys were mailed randomly with respondent anonymity guaranteed in order to obtain truthful answers to sensitive items such as socio-economic and health problem questions. The survey process comprised five parts: questionnaire design, implementation, testing, approval by the Auburn University Human Subjects review board, and selection of the population sample.

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[5] The mail survey study was funded by Auburn University's Department of Agricultural Economics with the support of Dr. Jolly and Dr. Hite.

4.4.1 Questionnaire Design

Calhoun County Risk Survey was designed to fit onto a single double sided 11" by 17" sheet of paper, folded in two (see Appendix D). The booklet style was preferred because it is fast and inexpensive to produce and easy to mail. The survey was reviewed by two experienced professors in surveying techniques: Dr. Diane Hite and Dr. Conner Bailey. The numerous comments and suggestions made by the reviewers were instrumental in enhancing the initial design of the mail survey. Crucial editing points were made to render the survey more appealing and easier to understand. The wording of some questions was altered: shorter and simpler questions were preferred to long and complex ones. Extra spacing was added and the ordering of the questions was rearranged to add a natural flow. Again, the survey started with simple questions to improve the chances of an individual in successfully completing the survey and providing meaningful data for my analysis. The socio-demographical questions were grouped together in the last section of the survey, like most surveys do. All these revisions were made to render the survey more appealing and easier to understand.

Implementation

The specific procedures for implementing a survey are many and vary with the mode of administration. In the case of the Calhoun County Risk Survey, funding was limited and scarce. Therefore, the most cost-efficient mode of administration was a mail survey. To successfully carry out a mail survey study, Dillman's (2000) standard procedures were meticulously followed. Dillman's method stresses the importance of the surveyor to follow-up several times with the individuals who did not respond to the initial mail out to increase the response rate. "A reasonable response rate is one that provides enough data for the desired analyses with an acceptable range of error and provides a group of respondents which characteristics similar to the broader population to which inferences will be made."

In addition to follow-up, other studies by Dillman show that hand signed cover letters and pre-paid postage return envelopes create receptiveness among the respondents and increase the survey's response rate. First class mail postage is also preferred to bulk mail postage because it shows that pride was taken in mailing the surveys. Also, the advantage of using first class rates is that the return to sender service is provided by the U.S. postal service. This extra feature enables the surveyor to discard bad addresses from his sample, and calculating his effective response rate. In this case, there was no way of knowing the effective response rate because the allocated budget for the mail survey study was not enough to cover the extra cost for first class mail.

In summary, the mail-out questionnaire was designed to be short and easy to complete in order to increase response. Following Dillman's tailored design methodology (A Dillman Don, 2000), the booklet style questionnaire was mailed along with a hand signed cover letter and a pre-paid postage return envelope.

Testing

A pilot survey is a small scale implementation of the final mail survey. The pilot survey serves several purposes. First it allows you to test the survey and find out if the targeted audience understands the questions and the directions on how to answer different types of questions. Second, having a pilot survey allows for a test of the survey implementation procedures. The survey was pretested with a group of 30 undergraduate and graduate students along with staff and faculty members from Auburn University, who provided further input into readability and length of the survey.

4.4.2 Human Subject Review

Ethical permission was obtained from the Office of Human Subjects Research of Auburn University. All academic studies that involve human subjects have to go through a rigorous ethical review process to protect participant's identity and confidentiality. An elaborate protocol of the study and data collection was drafted and submitted to the Institutional Review Board (IRB). The IRB protocol included the survey's timeframe, the selection process of potential candidates, data collection and storage and any risks involved in participating in the study. The IRB protocol form was finalized and submitted to the Office of Human Subjects Research end of October 2005 and was reviewed by the full board on the first Wednesday of November 2005. After the initial review, the board approved the protocol pending few minor corrections. On December the 2nd, 2005, the Auburn University Institutional Review Board granted final approval of our protocol. Fieldwork was completed over a four-month period between December 2005 and April 2006.

4.4.3 Sampling

In the following section, a detailed description of the sampling procedure for the different mailings (initial survey, postcard reminder and second survey) will be covered before the coding, data entry and analysis of the housing data.

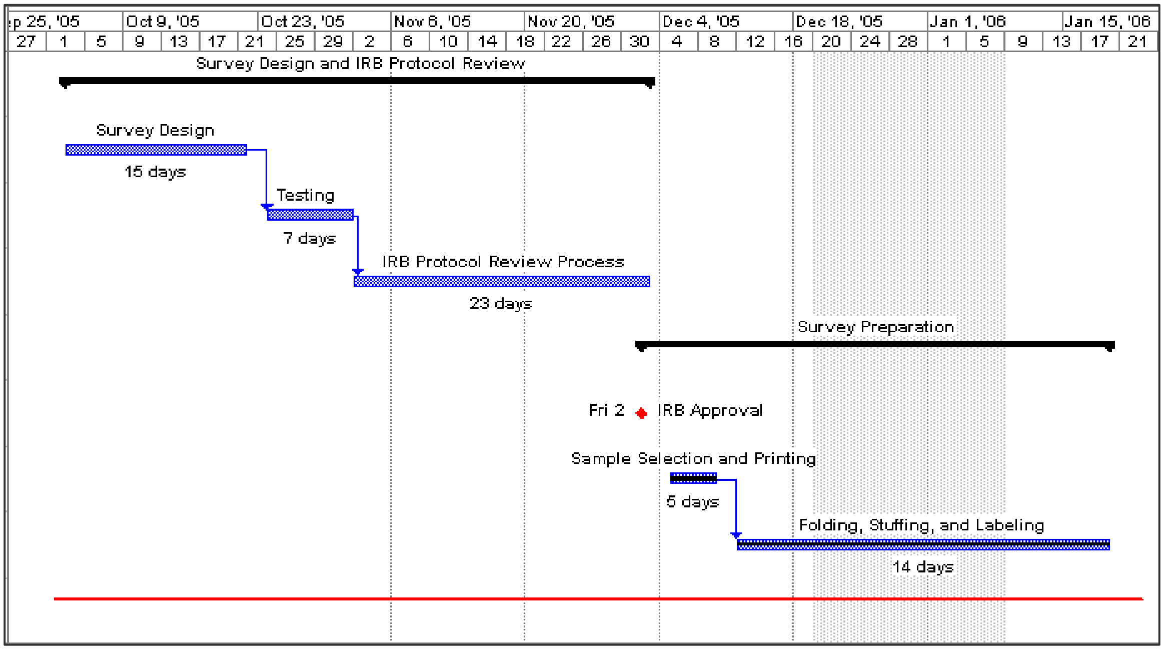

Figure 4. Survey design and preparation timeline

A representative sample was randomly selected and stratified by risk zones of the area surrounding the incinerator for the residential homes that were transacted between 1993 and 2005 using the property records of Calhoun County Revenue Department. The risks associated with the incinerator have been established by the Alabama Emergency Management Agency (AEMA), in conjunction with Calhoun County Emergency Management Agency (EMA) and the Chemical Stockpile Emergency Preparedness Program (CSEPP), which established risk zones in the area surrounding the incinerator (see figure 5 below).

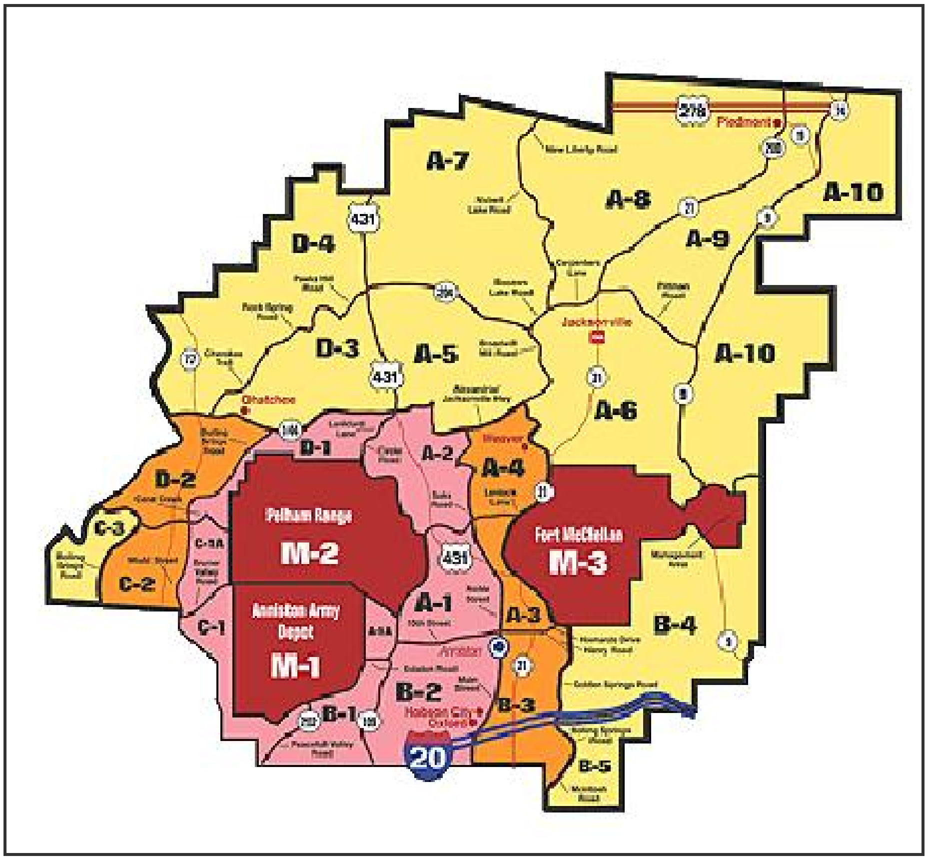

Figure 5. Map of the three risks zones within Calhoun County

The risks zones are determined by the proximity of the home to the Anniston Chemical Army Depot. These zones are pseudo-concentric and shaped to account for the prevailing winds and the risk level that is greater in the closest zone to the Army Depot. The "Pink Zone" also referred to as the Immediate Response Zone (IRZ) is the closest to the Aniston Army Depot and the one that has the greatest risk for the public. This zone encompasses an area requiring a less than one-hour responses time when affected by a chemical release. It extends approximately 9 miles, the average distance a chemical vapor plume could travel in one hour under typical weather condition. In case of an accident at the ANCDF, residents in the "Pink Zone" are instructed to stay indoors and shelter themselves using their shelter-in-place kit (protective hood, portable air filtration unit, plastic sheets, duct tape and scissors). The Protective Action Zone (PAZ) is an area of lesser risk than the "Pink Zone" and extends approximately 20 to 30 miles away from the Army Depot. This "Orange Zone" may require public protection actions. The protective action equipment provided to the citizens in the IRZ consists of a portable room air cleaner, plastic and duct tape to seal off the room from chemical vapors. Finally, homes located at a distance greater than 35 miles are zoned in the "Yellow Zone" or Precautionary Zone. This area has a minimal risk factor and adequate time exists to evacuate the residents prior to arrival of airborne chemical agents. As a result, a random stratified sampling procedure was employed to select individuals proportionally within the three risks zones. The sample size (3,500 individual family houses) was computed based on a desired 99% confidence level of the sampling estimates. Eligible respondents were adults between the ages of 18 and 90 years inclusive who owned a residential house in Calhoun County. A response rate of 22% was obtained.

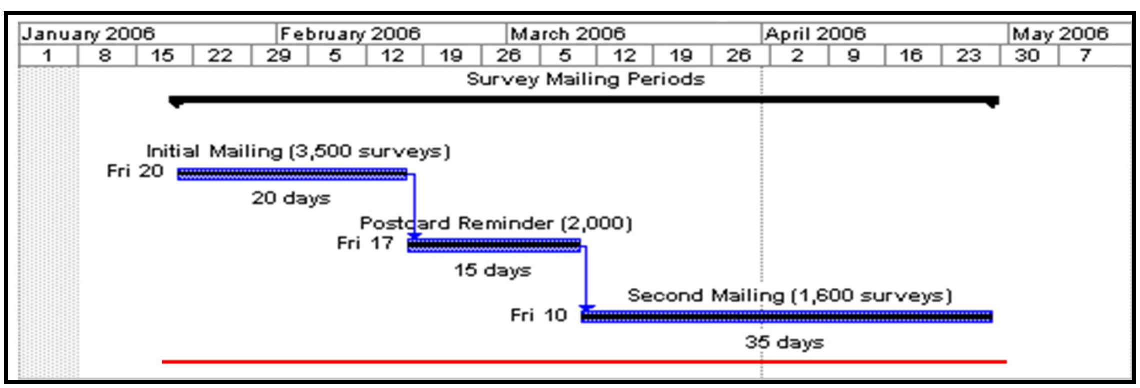

Figure 6. Time chart of the different survey mailing periods

An information letter about the importance of the study was sent, on January 17th 2006, to all selected individuals in Calhoun County along with the initial survey. A copy of the information letter can be viewed in Appendix C. The information letter stated how the participants were selected, noted that participant response was voluntary, and promised anonymity. Only aggregate, as opposed to individual survey results, were used in the analysis. Surveys were coded with a number corresponding to the address and once returned; surveys were identified only by that number when data was entered. These steps conformed to Auburn's human subjects review procedures.

Four weeks later, on February 15th 2006, a solar-yellow reminder postcard (see Appendix E) was sent to non-respondents to stress the importance of their participation in the study and to ask them to return the survey in a timely manner. For those hard-to-convince homeowners, who had not responded after three weeks upon receiving the postcard, a telephone follow up was initiated to see if they were interested in participating in our study. The purpose of calling up non-respondents was twofold: firstly it was an easy way to verify the accuracy of the resident's address and secondly it helped us keep our costs within budget limits by sending out the questionnaire only to those who were interested and willing to participate in the study. Finally, on March 9th 2006, an extra copy of the initial survey was mailed to those I could not reach by phone in case they had discarded the original one. The different mailing periods are represented graphically in the Microsoft Projects Gantt Chart in the above figure 6. Three months after the initial mail out, 741 surveys were returned, but because of item nonresponse, the final database consists of 730 usable surveys. Because of budgetary constraints, pre-sorted bulk mailing was used, so it is impossible to know the true response rate for the Anniston survey study.

4.5 Data Used in the Hedonic Price Model

For each single family home, information was obtained on the following three types of variables:

1. Structural variables (e.g. the number of rooms in each house);
2. Neighborhood variables (e.g. local poverty rates);
3. Environmental variables (e.g. distance to ANCADF)

The variables used in the model are listed in table 3 and are common to most statistical real estate appraisal models.

The dependent variable examined is the estimated price of a house in Calhoun County, Alabama. In order to obtain real house prices, the nominal house prices were deflated using the monthly CPI housing Index for small cities in the southern region of the U.S., with January 2007 as the base year (01/2007 = 100). The CPI was downloaded from the U.S. Department of Labor, Bureau of Labor Statistics website, which records the CPI on a monthly basis.

In terms of explanatory variables, the Calhoun County sales price data provided a variety of basic and aggregate information on housing-unit attributes. Data such as number of bedrooms, number of rooms, type of structure, age of the building, and square footage are available, along with dummy variables to capture the effect of a fireplace, patio, pool, and type of structure. Additionally, a Geographic Information System (GIS) analysis determined the longitude and latitude coordinates of the houses and computed the distances of each house to the two environmental disamenities sites (ANCADF and Solutia) and to the nearest waterway. Using GIS technology, I also linked each house to the demographic data of its census tract, city, and school district. Table 3 presents the descriptive statistics for the variables used in this analysis.

Table 3 Descriptive statistics of the variables included in the HPM

Variable	Mean	Std Dev.	Minimum	Maximum
REAL PRICE	81,466.61	65,216.86	1,497.97	1,355,689.23
URBAN POPULATION	0.50	0.50	0.00	1.00
UNDER_TRUE	0.60	0.49	0.00	1.00
UNDER*PCB	0.12	1.27	0.00	99.17
ACRES	12.05	38.49	0.48	865.69
ADJUSTED SQUARE FOOTAGE	2,038.04	841.08	269.00	13,956.00
ROOMS	6.13	1.41	1.00	16.00
FULL BATH	0.71	0.53	0.00	4.00
HALF BATH	0.27	0.45	0.00	3.00
GARAGE	0.10	0.30	0.00	1.00
FIREPLACE	0.57	0.50	0.00	1.00
POOL	0.09	0.28	0.00	1.00
STORIES	1.15	0.34	1.00	2.50
UTILITY BLDG	0.27	0.51	0.00	4.00
NO OF TRANSACTIONS	5.89	2.76	1.00	24.00
BUILDING AGE	34.97	20.65	1.00	146.00
PCB30M1000	0.19	1.36	0.00	99.17
DISTANCE TO INCINERATOR	17.83	7.21	4.97	47.89
COLLEGE DEGREE	19.97	12.70	1.02	62.17
WHITE	83.26	17.65	0.00	100.00
UNSKILLED LABOR	20.86	8.41	2.11	55.77
AIR RELEASE	0.08	0.41	0.00	3.99
CRIME RATE	11.00	3.81	3.60	14.53
CRIME PER CAPITA	0.01	0.00	0.00	0.03
DV_1971	0.98	0.14	0.00	1.00
DV_1993	0.66	0.47	0.00	1.00
DV_1996	0.47	0.50	0.00	1.00
DV_1999	0.32	0.47	0.00	1.00
DATE OF SALE	665.39	108.63	128.00	803.00
N: 9,655				

The mean housing sales price in 2007 dollars for the entire sample is $81,466.61. Of the sample 9,655 housing transactions, 66% occurred before 1993, 47% occurred before 1996 and 33% of the total sales transactions took place after 1999. The structural variables include the number of bedrooms, the number of bathrooms, the size of the lot in square feet, and whether there is a garage. The neighborhood variables include the median household income in the census tract, the proportion of blacks in the census tract, the proportion of people with a high school education in the census tract, the property tax district.

Omitted Variables

It is recognized from the outset that no econometric model can capture all the factors that are at work in a sophisticated market like that for housing. One of the main reasons for this is limited availability of statistical data, which constrains the scope of the economic analysis. However a stochastic term is included in the models to capture the effects of the independent variables that impact the dependent variable but which are not explained by those that are included in the hedonic price model.

4.6 Data Used in the Risk Perception Model

A stated goal of the Calhoun County direct mail survey was to obtain information on respondents' perceptions of the potential risks posed by various environmental disamenities, as well as risks associated with exogenous events, such as terrorist attacks or natural disasters damaging the chemical weapons incinerator.

Two different questions from the survey were used to measure the environmental impacts related to the non-stop operation of the ANCDF. To identify factors that determine perceived environmental risks, survey respondents were asked to rank four environmental risks in the area by order of importance using the following question.

Question 1: "What potential environmental risk factors are you most concerned with? Please order the following four environmental risk factors according to how important there were to you when you chose your current residence:

- Impact of Depot or Solutia on property value
- Possible health risks from pollution of soil or water
- Possible natural disaster affecting Army Depot
- Possible terrorist attack at the Army Depot

Data from question 1 was used to create two risk ranking variables need to develop the risk perception model. The first risk variable is the fear of a possible natural disaster affecting the chemical munitions stored at the Army Depot. Respondents who ranked natural disaster as the most important risk factor in question one were coded as 1 for the HIDISASTER variable. All other responses were given a zero value for the variable of concern. The second variable generated from the responses obtained from the survey was high terrorist attacks (HITERROR). In the same way HIDISASTER was coded, HITERROR indicates whether or not a possible terrorist attack on the depot is the survey respondents' number one fear. Only responses related directly to the incinerator are included

The second question that was used from the survey would allow to test whether or not prior information about the incinerator had a significant impact where homeowners' would invest in the real estate market. In most cases, knowledgeable homeowners pay higher marginal prices for homes less exposed to environmental risks, such as the handling of unstable chemical weapons at the Army site.

Question 2: "If you were to consider moving to a new neighborhood in the Anniston Area, would the operation of the incinerator at the Army Depot negatively influence your choice of neighborhoods?

- Yes
- No
- Don't know

The dummy variable (INCMOVE) reflects the influence of the incinerator on the future location. The responses from this question were recoded into a new binary variable, depending on of they answered yes or no to the above question. INCMOVE takes on a 1 value if the respondent answered "yes" to the question and 0 otherwise.

The risk perception model uses primary data obtained through the implementation of the Anniston Environmental Risk Survey. Models using survey data are typically faced with the problem of nonresponse bias. Nonresponse bias arises when the characteristics of the respondents are systematically different from the characteristics of the non respondents (D Hudson et al., 2004). Recipients who volunteer to participate in the survey study may have different characteristics than the average individuals in the target population. Thus, the survey data is not representative of the target population and all inferences made from this data will lead to distortion on the results. Selection bias is assumed to be present in the Anniston's survey results therefore a sample selection model was used.

The outcomes of each environmental risk are analyzed using a sample selection model. The basic structure of a selection model is defined by a selection mechanism, or probit model, and a regression model that is observed only for the part of the sample that is "selected", that is, responders. The model can be formulated as follow:

a. The selection mechanism models the probability that a survey recipient responded and is defined as:

$$\boldsymbol{Y_i^* = \beta_i' X_i + \varepsilon_i} \qquad \textbf{[4]}$$

Where, Y_i^* is set to one if an individual responds to the survey and zero otherwise. X represents a vector of demographic and other variables that explain the probability of survey participation, β represents the parameter vector, and ε represents the error term.

b. The regression model applied to the sample of individuals who have responded to the questionnaire is given by

$$\boldsymbol{W_i = \alpha' Z_i + \upsilon_i}, \text{ observed only if } Y_i^* = 1 \qquad \textbf{[5]}$$

Where, W is the natural log of the housing transaction price. Z represents a vector of housing, neighborhood and environmental variables that explain the price of a house, α represents the parameter vector, and υ represents the error term.

Equation [5] represents a regression of the survey participants. Specification of equation [5] is described in the next section. The assumption is that the error system follows a bivariate normal distribution; correlation between ε in equation [4] and υ in equation [5] lead to biased estimation if equation [5] is estimated alone.

More specifically, equation [5] can be rewritten as follow:

$$\textbf{Log(REAL\_PRICE)}_i = \alpha_0 + \alpha_1\text{*URBAN}_i + \alpha_2\text{* UNDER\_TRUE}_i + \alpha_3\text{*UNDER\_TRUE*PCB}_i + \alpha_4\text{*log(ACRES)}_i + \alpha_5\text{*SIZE}_i + \alpha_6\text{* ROOMS}_i + \alpha_7\text{*FULLBATH}_i + \alpha_8\text{*HALFBATH}_i + \alpha_9\text{*GARAGE}_i + \alpha_{10}\text{*FIREPLACE}_i + \alpha_{11}\text{*POOL}_i + \alpha_{12}\text{*STORIES}_i + \alpha_{13}\text{*UTILITY\_BLDG}_i + \alpha_{14}\text{*TRANSACTIONS}_i + \alpha_{15}\text{*log(BLDGAGE)}_i + \alpha_{16}\text{*PCB30M100}_i + \alpha_{17}\text{*log(INCINERATOR)}_i + \alpha_{18}\text{*UNEMPLOYED}_i + \alpha_{19}\text{*WHITE}_i + \alpha_{20}\text{*UNSKILLEDLABOR}_i + \alpha_{21}\text{*CRIMERATE}_i + \alpha_{22}\text{*HITERROR}_i + \alpha_{23}\text{*HITERROR*LNDIST}_i + \alpha_{24}\text{*HIDISASTER}_i + \alpha_{25}\text{*HIDISASTER*LNDIST}_i + \alpha_{26}\text{*INCINIRATOR\_MOVING}_i + \alpha_{27}\text{*COMMUTING\_TIME}_i + \varepsilon_i \text{, observed only if } Y_i^* = 1 \qquad \textbf{[6]}$$

The Selection Mechanism

In this study, the survey was based on a population of 1993-2004 housing transactions, for which data exists at the individual level on household structural and locational characteristics, and at the census block group level for demographic characteristics. Thus, although actual demographic data on individual survey nonrespondents may not be available, census block level data may be useful in estimating a sample selection model. To facilitate estimation of this model, the complete dataset of all 9,655 housing transactions, as described in section 4.1, was used.

The selection equation, given by equation [4] is specified as a probit model in which y = 1for those who participated in the survey, and y = 0 for those not participating. The stated hypothesis is that nonresponse might be related to such census block group characteristics as race, income and education. Individuals who had unknowingly purchased homes near disamenities but found out about them later might be less likely to respond. Thus the selection equation is defined as

$$\textbf{Prob}(\textbf{\textit{Participate}}) = \boldsymbol{f}(\textbf{\textit{demographics}}, \textbf{\textit{location}}) + \boldsymbol{\varepsilon} \qquad \textbf{[7]}$$

The variables used in the regression model include demographic variables from census micro data such as: percentage of males, percentage of singles (never married), percentage of residents with a bachelor degree, and poverty rate[6]. In addition to these four demographic variables, two housing characteristic were also added in the regression equation: log of adjusted square footage and the dummy variable (BARN). This dummy variable captures unobserved quality differential in the size of residential properties. It may also capture altruistic nature of individuals on farms who may be more likely to respond to the survey.

The regression portion of the model is very similar to the hedonic model described in section 3.2. However, some variables had to be dropped from the original model because the survey framework. For instance, all the time period variables were excluded from the sample selection model because there was either insufficient numbers of observations for those dummy variables or irrelevance of the timing of information on the more recent housing transactions. The survey's populations from which inferences are made are all the homeowners that have purchased a residential property between January 1993 and December 2004. Referring back on how these time dummy variables were constructed, it is apparent that both the 1971 and 1993 dummy variables cannot be specified. Indeed, because of the sampling technique, no homes were bought by survey

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[6] At the Census Block Group level.

recipients prior to 1993. For the same arguments, the date of sale's variable was also dropped. Further, because most respondents were clustered in Anniston, the air release variable (AIR_RELEASE) was dropped due to lack of data variability.

Table 4 Descriptive statistics of the risk perception model

Variable	Mean	Std Dev	Minimum	Maximum
Selection model (N = 3,463)				
RESPONSE	0.21	0.41	0.00	1.00
MALE	47.50	3.12	39.33	55.73
NEVER_MARRIED	19.70	6.41	11.14	71.54
BACHELOR_DEGREE	11.00	6.45	0.00	31.41
POVERTY_HH	9.68	5.13	3.92	27.64
LnSQFT	7.54	0.38	5.59	9.09
BARN	0.04	0.27	0.00	6.00
Regression model (N = 730)				
LNPRICE	11.09	0.99	7.32	12.79
URBANPOP	0.53	0.50	0.00	1.00
UNDER_TRUE	0.56	0.50	0.00	1.00
UNDER*PCB	0.14	0.82	0.00	14.22
ACRES	14.12	49.75	0.48	847.70
SQFT	2,167.30	897.60	557.00	8,874.00
ROOMS	6.28	1.45	1.00	16.00
FULL_BATH	0.76	0.57	0.00	4.00
HALF_BATH	0.28	0.46	0.00	3.00
GARAGE	0.12	0.32	0.00	1.00
FIREPLACE	0.57	0.50	0.00	1.00
POOL	0.09	0.28	0.00	1.00
STORIES	1.16	0.34	1.00	2.50
UTILITY_BLDG	0.28	0.54	0.00	3.00
NO_OF_TRANSACTIONS	5.13	2.61	1.00	18.00
BLDGAGE	34.54	21.33	2.00	106.00
PCB30M1000	0.24	1.11	0.00	14.67
DIST2INCIN	9.71	0.34	8.51	10.74
COLLDEG	0.40	0.49	0.00	1.00
WHITE_CT	82.36	18.31	0.00	100.00
PRODUCTION	20.56	8.41	2.11	55.77
CRIME PER CAPITA	0.01	0.01	0.00	0.03
HITERROR	0.16	0.37	0.00	1.00
HITERROR*LNDIST	1.54	3.54	0.00	10.74
HIDISASTER	0.27	0.44	0.00	1.00
HIDISASTER*LNDIST	2.61	4.31	0.00	10.69
INCMOVE	0.53	0.50	0.00	1.00
COMMUTING_TIME	23.43	25.76	0.00	180.00

[a] Variables used in the selection model were rescaled from the previous hedonic model due to convergence problems with the Maximum Likelihood Equation.

Comparing table 4 with the full model illustrated in table 3, the average PCB residential soil contamination is 23% greater for the respondents than the county average. The average PCB level is 0.19mg/kg at the county level compared to 0.24mg/kg for the survey respondents. Moreover, homeowners who voluntarily responded to the survey, live on average, 8 kilometers closer to the chemical incinerator than does the typical Calhoun County resident. These results show that individuals affected by the contaminations of the industrial facilities in West Anniston are more likely to partake in the survey study than those that live further away in higher environmental quality areas. Surprisingly, the average crime rate per capita is lower in the selection model than in the overall hedonic model. Since crime rate is not the issue of concern in the survey study, individuals who fear crime were perhaps less interested in responding to the survey. Another perfectly reasonable explanation is that crime affects every citizen regardless of where they live or work, but not everyone is affected by the adverse health effects of PCBs because unlike crime, the PCB contamination is localized in only the southwestern part of the county.

The means of the HITERROR and HIDISASTER variables can easily be interpreted as the proportions of respondents who ranked either one of these two possible events as highest. Thus, only 16% of the survey respondents are highly concerned about the risk of a terrorist attack devastating the chemical stockpile. The greatest fear of 27% respondents is of a natural disaster causing a chemical cataclysm at and around the Army depot. More individuals are concerned about the prolonged risk of storing aging chemical weapons than the threat of an unlikely terrorist attack.

CHAPTER 5

EMPIRICAL ANLYSIS AND RESULTS

This chapter presents and discusses the results of the econometric analysis of first, the traditional hedonic price model and then those of the risk perception model. For both models, the assumptions underlying the generalized methods of moments and the sample selection model, are tested to make sure that they are not violated and that the obtained estimates are robust and unbiased. The analysis includes tests for the model specification, multicollinearity, and heteroskedasticity. Autocorrelation was not tested in the hedonic price models, because time series analysis was not conducted. Following the tests for models, the regression estimates of both models are presented in tabular form and discussed.

5.1 The Hedonic Price Model

In this section, the hedonic price model is tested for multicollinearity, endogeneity and heteroskedasticity, all of which were present in the data. The final model was estimated using generalized methods of moments because heteroskedasticity was predominately present in the model but was suspected to come from many sources.

5.1.1 Tests for Models

Possible Multicollinearity

Multicollinearity is always a possibility in multiple regressions and this is especially true in house price hedonics. It refers to the existence of more than one exact (or very close) linear relationship among some or all of the explanatory variables of a regression model. Although the estimators are still BLUE7, the existence of multicollinearity between X1 and X2 can result in these independent variables having very large variances and covariances, which make precise estimation more difficult, often resulting in sign instability. As a result, there is a greater chance of a Type II error. Multicollinearity was diagnosed by observing the variance inflation factors (VIF). These factors measure the inflation in the variance of the parameter estimates due to collinearities that exist among the independent variables. As a rule of thumb, if a VIF greater than 10 then collinearity is large enough to affect the predicted values. In addition to the VIF test a correlation matrix is also created to check for the presence of multicollinearity which is not apparent. Both the VIF and the correlation matrix indicate a low level of correlation among the variables so in conclusion no extreme source of multicollinearity is present in the model.

Endogeneity Diagnosis and Correction

The Hausman-Wu test statistic applied on the model suggested evidence of endogeneity in the explanatory variables (Chi-Square = 3,495). Testing for different variables in the hedonic price model suggest that crime, distance to incinerator, college

[7] Best Linear Unbiased Estimators

degree and crime rate require instrumentation. Instrumental variables were obtained using variable ranking as Sieg et al. (2002).

Heteroskedasticity Diagnosis and Correction

One of the key assumptions of regression is that the variance of the errors is constant across observations. If the errors are heteroskedastic or have non-constant variance, then the parameter estimates are inefficient. The main problem with using housing characteristic data is the difficulty in pin-pointing the explanatory variables that have non-constant variance in their error terms across observations.

Housing attributes can be reasonably expected to give rise to heteroskedasticity. For example, depending on how well a house is maintained, housing prices can be expected to fluctuate more across older homes. Similarly, the topography of the parcel is another source of non constant variance because the price of houses built on steeper terrains will fluctuate more than those built on flatter parcels, *ceteris paribus*. For these reasons, heteroskedasticity was investigated.

White's test was used to test for heteroskedasticity. The null hypothesis states that the regression analysis portrays homoskedasticity and the alternative states that it does show heteroskedasticity. The heteroskedasticity test for the hedonic price function shows that the chi-square is equal to 1,758. The probability of the chi-square value obtained exceeding the critical chi-square value at the 1% level of significance is nearly zero.

This implies that the hedonic price model does have a heteroskedasticity problem. Therefore, there is enough statistical significance to reject the null hypothesis. To correct for heteroskedasticity, the Generalized Methods of Moments was used because the precise form of heteroskedasticity was unknown.

Unobserved Heterogeneity Diagnosis and Correction

Neglecting unobserved heterogeneity can have serious consequences for the interpretation of econometric results. Thus, to avoid biased estimators, heterogeneity was corrected for by using Generalized Methods of Moments coupled with an instrumental variable approach. As mentioned in the above section, GMM was also deemed necessary to correct for heteroskedasticity. The instrumental variables were deemed relevant by a test of over-identifying restriction (Hansen 1982, p.1049 of the SAS Manual). The parameter estimates from the GMM models differ only slightly from ordinary least squares, but they are now more efficient. The test of over-identifying restriction is significant at the 99% confidence level (Chi-Square=2,736), thus there is enough statistical evidence to accept the null hypothesis that the over-identifying restrictions of the model are valid. Therefore, the instrumental variables used in the hedonic model are statistically significant.

5.1.2The Effects of Environmental Factors on Housing Values

In the theoretical section I mentioned that some policy questions can be addressed using the information contained in the hedonic price model. One can establish whether or not there is a statistically significant marginal willingness to pay for an environmental improvement.

One of the hypotheses to be tested is that housing values decrease with proximity to the incinerator, *certeris paribus*. In the empirical model, the distance from the ANCADF is expressed in log form to correct for non-linearity. The relevance of this transformation can be tested by examining the adjusted coefficient of determination (R^2) of the model.

Table 5 Estimated hedonic price function results

Variable Name	Parameter Estimate	Std Error	t Value
INTERCEPT	9.1542	0.2480 ***	36.91
URBAN POPULATION	0.0427	0.0183 **	2.33
UNDER TRUE VALUE	-0.9006	0.0139 ***	-64.67
UNDER TRUE*PCB30M1000	0.3199	0.0995 ***	3.22
LNACRES	-0.0380	0.0110 ***	-3.46
ADJUSTED SQUARE FOOTAGE	0.2526	0.0213 ***	11.87
ROOMS	0.1854	0.0794	2.34
FULL BATH	0.1640	0.0219 ***	7.49
HALF BATH	0.0984	0.0205 ***	4.79
GARAGE	0.1080	0.0263 ***	4.10
FIREPLACE	0.0643	0.0162 ***	3.98
POOL	0.1347	0.0297 ***	4.54
STORIES	0.0844	0.0302 ***	2.79
UTILITY BLDG	0.0491	0.0143 ***	3.44
NO OF TRANSACTIONS	0.0114	0.0300 **	0.38
LN BUILDING AGE	-0.1016	0.0155 ***	-6.56
PCB30M1000	-0.4373	0.0812 ***	-5.38
LNINCINERATOR	0.0383	0.0225 *	1.70
UNEMPLOYMENT	-0.8115	0.2929 ***	-2.77
WHITE	0.2707	0.0616 ***	4.39
UNSKILLED LABOR	-0.5720	0.1128 ***	-5.07
AIR RELEASE	-0.0622	0.0196 ***	-3.18
CRIME PER CAPITA	-0.7065	0.1777 ***	-3.98
DV 1971	-1.0879	0.0662 ***	-16.43
DV 1993	-0.2104	0.0298 ***	-7.06
DV 1996	-0.1363	0.0266 ***	-5.12
DV 1999	-0.3455	0.0252 ***	-13.72
DATE OF SALE	0.0042	0.0002 ***	23.11

Dependent Variable: LnPrice
N: 9,655 R2: 0, 4599 R2 adjusted: 0,4614

*** Significant at the 1% level ** Significant at the 5% level * Significant at the 10% level

Table 5 above presents the general methods of moments estimates of the hedonic price function. Along with the structural and neighborhood variables, the specifications include measures of environmental quality in the vicinity of the house as proxied by distance to disamenities and local toxic releases. As discussed previously, the hedonic price gradient with respect to a good (such as a structural or neighborhood attribute) is equal to the marginal value of the good. A priori expectations are that the coefficients for the structural house variables are positive because they are consumer goods. The regression results are consistent with these expectations: an increase in a structural attribute increases the price of the house. All the estimates for the neighborhood variables also have the expected sign (positive for goods and negative for bads). However the parameter estimates for school quality and for the crime rate are not significantly different from zero. The estimated coefficient for the distance to the ANCADF site is positive and significant. This positive relationship between the house price and distance to the environmental disamenities implies that people are willing to pay higher prices to live further away from this major point-source pollution site.

One of the concerns about the distance proxy used in this study is that it also measures the distance to other neighborhood characteristics. Multiple environmental disamenities could exist at the same distance to the house as the Solutia plant and the Army Depot. These other disamenities would then be reflected in the distance variable thus creating a source of bias in our estimates. The six mile radii variables from both sites address this concern by controlling for other environmental disamenities in the area. The coefficient estimates of these disamenity variables indicate a negative and significant price effect.

One would assume that with increased levels of PCBs, house prices would be reduced. As a result, an inverse relationship is expected between the level of PCB on the property and the dependent variable, house prices. According to the regression results in table 5, the regression coefficient on the PCB contamination level (-0.4373) indicates that a 10% increase in the amount of PCBs in the yards of homeowners would generate a 43.73% reduction in market value.

The regression coefficient on the logarithmic of the distance to the incinerator (LNINCINERATOR) is 0.0383, which indicates that, on average, a 10% increase in distance to the incinerator will generate a 3.83% increase in selling price. The natural log specification of the distance variable allows for the effect of the incinerator to decrease at a decreasing rate as distance increases. Nonetheless, houses built further away from the incinerator facility are always more desirable.

The crime rate is developed based on crime statistics from the F.B.I. and the U.S. Justice Department. The F.B.I. provides unified crime reports for major U.S. cities[8]. To calculate each city's annual crime rate, the F.B.I combines eight crimes divided into two categories: violent crimes and property crimes. These offenses include murder, forcible rape, robbery, aggravated assault, burglary, larceny-theft, motor vehicle theft, and arson. The sum of counts of these above offenses yields the total number of crimes by cities. The crime rate is simply the total number of crimes per 100,000 city dwellers.

In the first runs of the model, crime rate was not significant and had the wrong sign, which is against the common assumption that prices of homes decline as the crime level increases. Crime rate is a key variable for measuring neighborhood quality and is

[8] For all cities greater than 10,000 inhabitants

used in many empirical hedonic price models. One of the problems encountered with the crime variable being aggregated at the city level was that it did not allow for much variation. Meanwhile, all the rest of the data was either compiled at the census block group (CBG) level or at the individual housing unit. To capture the level of crime rate on the dependent variable, crime rate was weighted by the total population of a census block group in order to capture effects of differing populations across the county. By doing so, the crime rate variable obtained from the FBI was weighted by the inverse number of people at the CBG level. Again, an inverse relationship between crime rate per capita and house prices is expected. As crime rate per capita declines, house values would be expected to rise.

The next explanatory variable is unemployment (production - level of unskilled labor), which has been chosen as a proxy variable for economic growth (wealth). I expect a high positive correlation between the unemployment level and the house prices and a high negative correlation between the level of unskilled labor and the house prices.

As already mentioned, the regression coefficients on the dummy variables is a direct measure of the percentage impact on the price of houses. Thus, the results indicate that a presence of a fireplace adds 6.43% to the value of the house, while an outdoor pool typically adds 13.47% to the market value. On the other hand, houses that were sold after 1971, sold at an average discount of 1.08% compared to if it were sold before the year when Monsanto stopped producing PCBs at the Anniston plant. Correspondingly, houses sold after 1993, 1996 and 1999, sold respectively at an average discount of 0.21%, 0.13% and 0.34%. The major events that occurred in the four aforementioned years had, on average, a negative impact on the real estate market. To better understand the impact of these time periods on the housing price, implicit price change analysis is necessary.

Marginal implicit prices are derived from the partial derivatives of the predicted hedonic price function with respect to the variable of interest. In this case, the variables of interest are the continuous environmental quality variables. According to table 6, poorer air quality and higher PCB soil concentration levels decrease the mean house value by $3,820.77 and $14,448.23. A similar result is found with the distance to incinerator variable. For every additional kilometer the house is displayed away from the incinerator its mean value will increase by $2,390.24, ceteris paribus. Houses located closer to the incinerator sell at a lower price than if they were situated further away. By far, the biggest environmental impact stems from PCB contamination. This result is of no surprise because first millions of pounds of PCBs have been released into the environment for almost a half century and the PCB contamination site is well documented by the EPA, ATSDR, and Solutia. Secondly, PCBs are in resident's yards, which they can have tested to know the exact level of pollution. Finally the extensive media coverage of the two major lawsuits (Albernathy v. Monsanto and Tolbert v. Monsanto) has greatly contributed to informing the local community, and to a broader extend, the nation as the topic gained national awareness. The CBS network television show, 60 Minutes, broadcast on November 10, 2002 had a special documentary on the "toxic town" of Anniston, Alabama.

Table 6 Marginal implicit prices for continuous environmental quality variables

Variable	Mean	Std Error	Minimum	Maximum
IP PCB30M1000	-14448.23	84.46	-227293.51	-637.04
IP DISTANCE TO INCINERATOR	2390.24	10.60	134.43	29721.30
IP AIR RELEASE	-3820.77	22.34	-60106.76	-168.46
IP ACRES	-721.46	7.85	-10277.50	-1.74
IP ADJUSTED SQUARE FOOTAGE	11690.22	68.34	515.43	183905.53
IP FULL BATH	12839.85	75.06	566.12	201991.09
IP HALF BATH	7797.28	45.58	343.79	122663.50
IP STORIES	4802.18	28.07	211.73	75545.86
IP GARAGE	5164.44	30.19	227.71	81244.82
IP UTILITY	3753.48	21.94	165.49	59048.13
IP NO OF TRANSACTIONS	-5002.75	29.25	-78701.10	-220.58
IP BUILDING AGE	-528.69	9.16	-19867.23	-6.46
IP COLLEGE DEGREE	12580.51	73.55	554.69	197911.33
IP WHITE	18370.69	107.39	809.98	288999.93
IP UNSKILLED LABOR	-49247.24	287.90	-774736.78	-2171.36
IP CRIME PER CAPITA	-46181.35	269.98	-726505.40	-2036.18
IP DATE OF SALE	360.04	2.10	15.87	5664.01

N= 9,655

To examine the total impact of information, house prices are calculated as if no information had been announced (Table 7). In a hypothetical closed type market, with no information in play, the mean predicted baseline house value would then be \$300,186 (in 2007 dollars). Now, adding in the effects of information on real estate values, the mean predicted price effect of PCBs on housing values is -\$199,012 (in 2007 \$). This information significantly shifted downwards the housing market. Indeed, a homeowner who sold his house after 1971 could have sold it for more than double the price if he would have sold it prior to 1971, ceteris paribus. In 1993, the Unites States signed the United Nations Chemical Weapons Convention and the EPA started accessing the extent of the PCB contamination which resulted in fish consumption advisory. The mean predicted marginal effect of this information, revealed in 1993, reduced housing values by $19,800 (2007 $). The construction of the chemical weapons demilitarization facility and the closing of Fort McClelland both resulted in further decreases of the mean predicted price respectively by $11,682 and $20,176.

Table 7 Hedonic price shifts by periods

Variable	Mean	Std Dev	Minimum	Maximum
Predicted Baseline	300,186.37	267,715.72	8,126.78	5,741,666.99
IP 1971	-199,012.12	177,485.32	-3,806,506.31	-5,387.75
IP 71-93	-218,812.78	195,144.18	-4,185,233.71	-5,923.80
IP 71-96	-230,495.31	205,563.03	-4,408,685.63	-6,240.07
IP 71-99	-250,671.38	223,556.69	-4,794,593.43	-6,786.29

N: 9,655

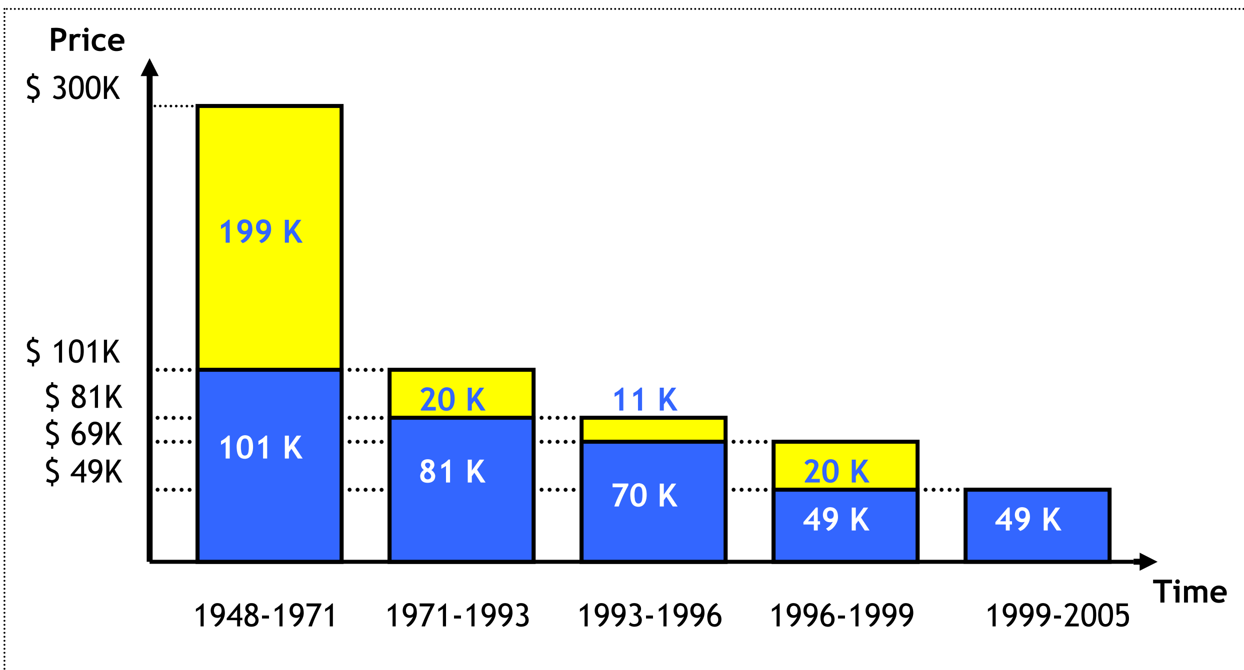

Figure 7. Effects of information on house values

According to the above figure, price changes in residential properties are represented by the top part of the bar chart (yellow section). Adding up these price change amounts will yield the total current dollar value impact of revealed information on the housing market.

5.2 Model of Risk Perception Impact

Table 4 presents the descriptive statistics of all the variables used in the risk perception model. The risk perception model was derived from the hedonic price model, described in previous sections, but includes additional variables to account for environmental risks. The empirical model used for this study is similar to the model developed by Ted Gayer (2000). The results of the risk perception model are presented here below in Table 9.

Table 8 Estimated risk perception function results

Parameter	Estimate		Standard Error	t Value
Selection model (N = 730, Log Lkelihood= -109,415)				
Dependent variable: LnPRICE				
INTERCEPT	12.9638	***	0.1032	125.63
URBANPOP	-0.0054		0.0055	-0.99
UNDER_TRUE	-0.3838	***	0.0049	-78.58
UNDER*PCB	0.0144	***	0.0034	4.21
LNACRES	0.0115	***	0.0026	4.42
SQFT	0.1620	***	0.0065	24.79
ROOMS	-0.0162	***	0.0024	-6.87
FULL_BATH	0.0972	***	0.0059	16.37
HALF_BATH	0.0266	***	0.0055	4.83
GARAGE	0.0953	***	0.0097	9.87
FIREPLACE	0.0780	***	0.0049	15.88
POOL	0.1082	***	0.0077	14.08
STORIES	0.0596	***	0.0080	7.43
UTILITY_BLDG	0.0107	***	0.0038	2.80
NO_OF_TRANSACTIONS	-0.0077	***	0.0009	-8.78
LNBLDGAGE	-0.1736	***	0.0042	-41.21
PCB30M1000	-0.0271	***	0.0020	-13.53
DIST2INCIN	0.0278	***	0.0103	2.70
COLLDEG	0.0499	***	0.0047	10.64
WHITE_CT	0.0013	***	0.0002	7.01
PRODUCTION	-0.0062	***	0.0005	-11.96
CRIME PER CAPITA	-3.9422	***	0.5725	-6.89
HITERROR	-0.0760		0.1994	-0.38
HITERROR*LNDIST	0.0183		0.0207	0.88
HIDISASTER	-1.2031	***	0.1736	-6.93
HIDISASTER*LNDIST	0.1240	***	0.0180	6.88
INCMOVE	-0.0300	***	0.0043	-6.94
COMMUTING_TIME	-0.0006	***	0.0001	-6.82
Sigma	1.3396	***	0.0070	192.65
Regression model (N = 3,463 Log Likelihood= -90,524)				
Dependent Variable: RESPONSE				
INTERCEPT	-3.4481	***	0.0749	-46.02
MALE	-0.0034	***	0.0006	-5.52
NEVER_MARRIED	-0.0002		0.0004	-0.52
BACHELOR_DEGREE	0.0011	**	0.0004	2.48
POVERTY_HH	-0.0054	***	0.0006	-9.65
LnSQFT	0.3720	***	0.0095	39.03
BARN	0.1267	***	0.0042	30.26
Rho	-0.9967	***	0.0001	-7814.30

*** Significant at the 1% level ** Significant at the 5% level * Significant at the 10% level

As noted in table 8, among the two high risk situation variables included in the model, only HIDISASTER is significant and negative. The a priori assumption on the sign of the variable HIDISASTER is as expected. Homeowners living in the vicinity of the chemical weapons incinerator are most worried about severe weather conditions (thunderstorms, tornadoes) and possibly even earthquakes rattling the stored munitions and detonating them thus creating a catastrophic situation that would affect their health and environmental quality. The risk of a natural disaster affecting the stockpiled chemical agents is correlated with lower residential values. However the fear of a natural disaster affecting the stored chemical agents decreases as distance to the incinerator increases. Thus, homeowners living further away from the Anniston Army Depot are less concerned about the negative impacts of a natural disaster affecting their real estate wealth. Indeed, the estimate of the interaction variable, HIDISASTER*LnDISTANCE, is positive (0.1240) and significant at the 99% confidence level. The negative correlation of HIDISASTER with house price decreases as distance to incinerator increases.

The expected impact of the incinerator on future real estate investments is negatively correlated with housing values and significant at the 99% confidence level. As a result, individuals might use prior information about the chemical demilitarization at ANAD to bid down the price of houses located close to the facility, or they could relocate further away and willing to accept to pay more for better environmental quality. Either way, current homeowners who were surveyed will consider the effects of the chemical weapons incinerator next time they purchase a residential property.

CHAPTER 6

CONCLUSIONS AND FUTURE IMPROVEMENTS

This purpose of this research is to quantify how Anniston's hazardous sites affected the prices of homes and homeowner's welfare. The results were obtained by using a hedonic pricing model and a risk perception model, one to model the price of homes before the siting of the incinerator, and the other for modeling housing values after. Both models include variables related to the structure of the house, neighborhood and the surrounding environment.

The results show that the impact of the PCB contamination in Anniston on housing values widely surpasses those of the chemical incinerator. They also show that the two industrial facilities located in West Anniston have adverse effects on the residential property values: higher concentration levels of PCB or air releases significantly reduce housing prices, the further a house is located away from these facilities, the higher the price, keeping all else equal.

In terms of marginal impacts, if a property's soil concentration of PCB were to increase by 1mg/kg then the price of the house will be devaluated on average by approximately $15,000. The average marginal impact of the chemical incinerator is only $2,400 per kilometer. In addition, poor air quality adversely affects housing values. The negative marginal impact of air quality is $3,800 on average. Thus if one were to increase by one pound the air releases in a community, the price of the average home in that community will drop by $3,800, ceteris paribus.

One of the arguments explaining the high property impacts caused by PCBs is that the pollution and adverse health effects are apparent. Many residents in west Anniston have had their soils tested for PCB levels and other heavy metals at least once in the past decade. Some have undergone further screening, and have had their blood checked for traces of abnormal high levels of PCBs. While there has not yet been a major catastrophic accident at the incinerator, homeowners are not too concerned about the incinerator in respect to PCBs.

The results from the risk perception model show that homeowners risk perception varies with exposure to disamenities. Indeed, the negative correlation of HIDISASTER with house price decreases as distance to the incinerator increases. Individuals who live further away from the army facility are les worried about the risk of a natural disaster significantly deflating their housing values. Additionally, high perceived risk of a natural disaster is correlated with lower residential property values.

The risk of an accident occurring at the chemical weapons incinerator is assumed to be low and hypothetic, but if it were to happen then the spread of the contamination would affect every homeowner in Calhoun County. On the other hand, the risks associated to the PCBs contamination are high but only concerns a well delimitated area in west and southwest Anniston.

The data collected and the models developed for this thesis could be used to analyze the impact of other contaminants or disamenities present in Anniston, for example lead and possibly mercury.

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APPENDICES

APPENDIX A

GLOSSARY OF SELECTED TERMS AND ACRONYMS

The following is a glossary of selected terms and acronyms, some with descriptions.

A

ACWA............................	Assembled Chemical Weapons Alternatives
ADEM…………………..	Alabama Department of Environmental Management
Agent...............................	lethal chemical vesicants and nerve agents: VX, GB, HD, T, H or HT (ACWA) and GD, GB
AL..................................	Alabama
ANCDF............................	Anniston Chemical Agent Disposal Facility
AR..................................	Arkansas
ATSDR…………………..	Agency for Toxic Substances and Disease Registry, U.S.
AWIC……………………	Alabama Water Improvement Commission

B

BLS................................	Bureau of Labor Statistics
BGAD.............................	Blue Grass Army Depot
BGCAPP.........................	Blue Grass Chemical Agent Destruction Pilot Plant
BRAC……………………	Base Realignment and Closure Commission

C

CAC……………………..	Citizens Advisory Councils
CADF……………………	Chemical Agent Disposal Facility
CAP……………………..	Community Against Pollution
CDC……………………..	Center of Disease Control, U.S.
CDF................................	Chemical Demilitarization Facility
CERCLA.........................	Comprehensive Environmental Response, Compensation, and Liability Act
CMA...............................	Chemical Materials Agency
CMSA…………………..	Consolidated Metropolitan Statistical Area
CO..................................	Colorado
CPI………………………	Consumer Price Index
CS……………………….	Consent Order
CW.................................	Chemical Weapons
CWC...............................	Chemical Weapons Convention
CWWG…………………..	Chemical Weapons Working Group

D

DOD……………………..	Department of Defense
DOT................................	Department of Transportation (US)

E

ECR..................................	Explosion Containment Room
EPA……………………...	Environmental Protection Agency
Explosive...........................	An *energetic* substance or compound that rapidly produces gas and heat upon decomposition.

F

Facility.............................	The structure or group of buildings used to perform any of the consecutive steps in the unloading, disassembly, neutralization, demilitarization, or salvaging of an assembled chemical weapon, its components, its chemical and explosive fills or their stimulants.
FAO……………………...	Food and Agriculture Organization of the United Nations
FBI……………………....	Federal Bureau of Investigation
FEMA……………………	Federal Emergency Management Agency
FDA……………………...	Federal Drug Administration

G

g.......................................	grams
GB....................................	Sarin, a nerve agent (isopropyl methylphosphonofluoridate)
GIS………………………	Geographical Information Systems

H

HD……………………….	Mustard Gas
Hg……………………......	Mercury's symbol based on the Greek word *hydrargyrum*
HPF.................................	Hedonic Price Function
HPM.................................	Hedonic Price Model

I

Igloo.................................	a type of earth-covered munitions storage magazine, often associated with the storage of CWM
IRB………………………	Institutional Review Board

J

JACADS............................	Johnston Atoll Chemical Agent Disposal System
JI.......................................	Johnston Island, location of JACADS

K

KY....................................	Kentucky

L

lb.......................................	pound
Leaker................................	CWM indicating leakage of chemical agent

M

Micro................................	10^{-6} (1 PPM)
MSA……………………..	Metropolitan Statistical Area
Munitions.........................	the components and process related materials present in a fully assembled chemical weapon.

N

NCEH……………………	National Center for Environmental Health
NEPA……………………	National Environmental Protection Act
NPL……………………...	National Priority List
NRC................................	National Research Counsel

O

ONC................................	On-site Container
OR...................................	Oregon
OSHA……………………	Occupational Safety and Health Administration
OU………………………	Operable Units

P

Pa....................................	Pascal (98,100 Pa = 1 N/m^2 = 1 atm = 14.7 PSI)
Pb………………………..	Lead's symbol is an abbreviation of the Latin word *plumbum*
PBCDF.............................	Pine Bluff Chemical Agent Disposal Facility
PCS………………………	Permit Compliance System
PMSA……………………	Primary Metropolitan Statistical Area
POP……………………...	Persistent Organic Pollutant
PPB………………………	Parts Per Billion
PPM……………………...	Parts Per Million
Propellant.........................	formulation of energetic materials to provide gas propulsion

Q

QC...................................	quality control
QRA................................	Quantitative Risk Assessment

R

RAC................................	Risk Assessment Code
RAGS……………………	Risk Assessment Guidance for Superfunds
RCRA……………………	Resource Conservation and Recovery Act
RHS.................................	Rocket Handling System
RI………………………..	Remedial Investigation
RMD................................	Risk Management Directorate (CMA)
RSS..................................	rocket shear station, shears M55 rockets into sections
RTF..................................	Rocket Task Force (CMA)

T

Tooele...............................	location of TOCDF and CAMDS
TOCDF.............................	Tooele Chemical Agent Disposal Facility
TRI………………………	Toxic Release Inventory

U

UMCDF...........................	Umatilla Chemical Agent Disposal Facility
UN………………………	United Nations
USGS……………………	United States Geological Survey

V

VOC…………………….. Volatile Organic Compounds
VX.................................... nerve agent, 0-Ethyl-S-(2-diisopropylaminoethyl) methyl phosphonothiolate

W

WHO……………………. World Health Organization

Y

yr...................................... year

APPENDIX B

LIST OF ANNISTON INDUSTRIAL OPERATIONS

Names	**Location**
Alabama Pipe and Foundry	McCoy Avenue between 18th and 20th St.
Anchor Metals	1008 Glen Addie Avenue
Central Foundry	1428 West 10th Street
Donoho Foundry	1100 West 10th Street
Emory Foundry	1000 Front Street
FMC Forge	2101 West 10th Street
FMC Foundry	2412 Eulaton Road
Huron Valley Steel	820 Ware Street
Interstate Roofing & Foundry Co.	402 South Noble Street
Kennedy Pattern & Foundry	200-300 Block of Front Street
Lee Brothers Foundry	West 17th and Walnut Street
M&H Valve	605 West 23rd Street
Solutia	702 Clydesdale Avenue
Ornamental Foundry	1205 Front Street
Peerless Pipe and Foundry	1906 West 13th Street
Standard Foundry	600 West 21st Street
Union Foundry	1501 West 17th Street
United States Casting Company	1831 Front Street
Water Pipe Plant	Alexandria Street between 25th & 27th St.
Woodstock Iron and Steel	13th Street and Duncan Avenue

Source: Section 122 Administrative Agreement and Order on Consent for Removal Action. CERCLA-04-2005-37777

APPENDIX C

LETTER OF INFORMATION

Auburn University
Auburn University, Alabama 36849-5406

College of Agriculture

Department of Agricultural Economics
and Rural Sociology
202 Comer Hall

Telephone: (334) 844-4800
FAX: (334) 844-5639

INFORMATION SHEET
For Anniston Environmental Risk Survey

Dear Homeowner/Renter,

We, Sa Ho and Christophe de Parisot, two graduate students at Auburn University are asking you and other Calhoun County residents to help us better understand the ways in which you are affected by environmental conditions in your neighborhood. We hope to determine the impact of Anniston's incinerator and PCB contamination on housing prices, health, and labor productivity. This research will be used to help form public policy regarding environmental issues in Calhoun County, and it is important for you to make your opinion known.

In the 2005 *Anniston Environmental Risk Survey* which follows, we will be asking that the head of the household answer questions about perceived risks from the chemical weapons incinerator and PCB pollution in your neighborhood. If the person to whom this questionnaire was addressed has moved, then we ask you to fill it in. Please do not forward the questionnaire since it is important that the person currently living at the address on the envelope answer our questions. It is unnecessary for you to reveal your identity. Please take about fifteen to twenty minutes to answer our questions. Your participation in this project is extremely important, whether or not you are interested in these issues. A postage paid return envelope is enclosed. Your prompt response will be appreciated.

Your answers will be kept strictly confidential and will not be linked to you by name and/or address. No individual's name or address will ever be published in any of our studies, and only average statistics will be used. Your identity will never be divulged to any outside sources.

Should you have any questions about this questionnaire, please call or email us at either number or address below. You may also contact our faculty advisor, Dr. Hite at (334) 844-5655 or at hitedia@auburn.edu with questions. For more information regarding your rights as a research participant you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu .

Sincerely,

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A LAND-GRANT UNIVERSITY

APPENDIX D

SURVEY QUESTIONNAIRE

Auburn University - Department of Agricultural Economics & Rural Sociology - 209B Comer Hall - Auburn, AL 36849 - Tel: (334) 844-5682

IMPORTANT DIRECTIONS FOR MARKING ANSWERS - PLEASE READ FIRST

- Please be sure to check the box when marking your response.
  Example: Incorrect marks: ■ Correct Marks: ☒ or ☑
- When checking boxes, please check only ONE box.

You have been randomly selected to participate in a research study and we invite you to please take the time to complete our survey and mail it back to us using the prepaid envelope. We ask that the survey be completed by an adult in the household.

Any information you provide will be strictly confidential. This data will be used only by persons engaged in this survey, and will not be disclosed or released to others for any purpose.

1. Do you own or rent your home?
   □ Own □ Rent →**GO TO 4**

2. If you own your home, to your best knowledge, what was the price asked by the previous owner or builder, and approximately how much did you actually pay for your house?
   Asking Price $________________ Purchase Price $________________

3. If you own your home, was it an existing structure or newly built when you bought it?
   □ Existing □ Newly Built

4. How long have you lived at your current address? _____Years _____Months

5. Did you move to your current home from
   □ Out of state □ Within Alabama but outside Calhoun County □ Within Calhoun County

6. Do you live on a farm and are you actively engaged in farming?
   □ Yes □ No

For questions 7 to 11, put a "1" next to the most important factor, a "2" next to the second most important factor, and so on down to "4".

7. When deciding where to live, locational factors are often taken into consideration. Please order the following four locational factors according to how important they were to you when you chose your current residence.
   ____ House is close to work place ____ House is close to friends and/or family
   ____ House is close to school ____ House is close to shopping and entertainment

8. When deciding where to live, neighborhood quality factors are often taken into consideration. Please order the following four neighborhood factors according to how important they were to you when you chose your current residence.
   ____ Neighborhood has lakes, trees, parks, etc. ____ Neighborhood has people with the same background
   ____ Chemical incinerator is not nearby ____ No nearby industrial pollution (PCBs and lead)

9. When deciding where to live, housing quality factors are often taken into consideration. Please order the following four housing quality factors according to how important they were to you when you chose your current residence.
   ____ This was the only place I could afford to live ____ The house has central air-conditioning
   ____ The house has up-to-date interior appliances ____ The size and numbers of rooms in the house

10. What potential environmental risk factors are you most concerned with? Please order the following four environmental risk factors according to how important they were to you when you chose your current residence.
   ____ Impact of Depot or Solutia on property value ____ Possible health risks from pollution of soil or water
   ____ Possible natural disaster affecting Army Depot ____ Possible terrorist attack at the Army Depot

11. Overall, please rank locational, neighborhood quality, housing quality and environmental risk factors in order of their importance to you when you chose your current residence.
   ____ Locational factors ____ Environmental risk factors
   ____ Neighborhood quality factors ____ Housing quality factors

12. If you were to consider moving to a new neighborhood in the Anniston area, would the operation of the incinerator at the Anniston Army Depot negatively influence your choice of neighborhoods?
   □ Yes □ No □ Do not know

13. Please rate your home in terms of general construction quality and quality of interior appliances
   □ Above average □ Average □ Below average

14. In your opinion, how much attention is given to environmental issues by local, state and federal government?
   □ Too much □ Too little □ Right amount

15. In your opinion, how much attention is given to environmental issues by the media?
   □ Too much □ Too little □ Right amount

16. Are you currently □ Employed □ Unemployed □ Retired □ Disabled

17. Even if you did not work last week, did you have a job or a business at any time in the PAST 12 MONTHS?
   □ Had a job last week □ No job last week, no job last 12 months → **GO TO 26**
   □ No job last week, had job last 12 months □ Do not know → **GO TO 26**

18. How many hours a week total do you work at (all of) your job(s)?________Hours

19. During the PAST 12 MONTHS, about how many days did you miss work at a job or business due to illness or injury (do not include maternity leave)? _________ days

20. Do you work at home for pay? □ Yes □ No

21. Do you work in downtown Anniston or Oxford? □ Yes □ No

22. Do you work at the Army depot? □ Yes □ No

23. Do you work at the Solutia plant? □ Yes □ No

24. Do you work on a farm? □ Yes □ No

25. How many minutes a day do you spend commuting to and from your job or jobs?_______ minutes

26. During the PAST 12 MONTHS, about how many days was your activity restricted due to illness or injury? _______ days

27. During the PAST 12 MONTHS, about how many days did illness or injury keep you in bed more than half of the day? ________days

28. How often do you drink any type of alcoholic beverage?
□ Never □ Daily □ Weekly □ Monthly □ Yearly □ Do not know

29. How often do you usually eat fruits and/or vegetables?
□ Never □ Daily □ Weekly □ Monthly □ Yearly □ Do not know

30. How often do you do any type of exercise or physical activity?
□ Never □ Daily □ Weekly □ Monthly □ Yearly □ Do not know

31. How often do you smoke cigarettes?
□ Every day □ Some days □ Not at all

32. Do you have any type of health insurance or health care coverage?
□ Yes □ No

33. Have you ever been told by a doctor or health professional that you have cancer or a malignancy of any kind?
□ Yes □ No → **GO TO 35** □ Do not know → **GO TO 35**

34. How old were you when cancer was first diagnosed? ___________ years

35. Have you ever been told by a doctor or other health professional that you have asthma?
□ Yes □ No → **GO TO 37** □ Do not know → **GO TO 37**

36. During the PAST 12 MONTHS, how many days were you UNABLE to work because of your asthma? ______ days

37. Have you ever been told by a doctor or other health professional that you have chronic bronchitis?
□ Yes □ No □ Do not know

38. During the PAST 12 MONTHS, did you have severe headaches or migraine?
□ Yes □ No □ Do not know

39. During the PAST 12 MONTHS, how many times have you had to visit an emergency room or urgent care center? _______ times

40. Do you have a well at home?
□ Yes □ No → **GO TO 42**

41. Do you rely on this well for drinking water?
□ Yes □ No

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42. How do you evaluate your general health?
    - □ Excellent □ Good □ Fair □ Poor

43. How many persons 18 years of age or older, besides yourself, usually live in your household? ________

44. How many children under age 18 live in your household at least one-half of the time? ________

45. If you have children in elementary or high school, do the children attend
    - □ Public Schools □ Private Schools □ Both

46. What is your age? ___________ Years

47. What is your race?
    - □ White □ Asian or Pacific Islander □ American Indian, Eskimo or Aleut
    - □ African-American □ Other race

48. How much school have you completed?
    - □ Less than 9th grade □ 9th to 12th grade, no diploma □ High School Graduate or equivalent
    - □ Associates Degree □ Some College, no degree □ Bachelors Degree
    - □ Graduate or professional degree

49. What was the total household annual income earned before taxes in 2004 through wages, salary and bonuses by all persons in your household?
    - □ Under $10,000 per year □ $10,000-19,999 per year □ $20,000-$29,999 per year
    - □ $30,000-$39,999 per year □ $40,000-49,999 per year □ $50,000-$59,999 per year
    - □ $60,000-$99,999 per year □ $100,000-149,999 per year □ Over $150,000 per year

50. What is your sex? □ Male □ Female

51. What is your marital status? □ Single, never married □ Married
    - □ Divorced □ Widowed

52. Have you or has anyone in your household made a contribution of time or money in the past 2 years towards environmental causes such as the Sierra Club, National Wildlife Federation, or Community Against Pollution, etc.?
    - □ Yes □ No

53. Did you vote in the last national election?
    - □ Yes □ No

APPENDIX E

POSTCARD REMINDER

Christophe de Parisot and Sa Ho
Graduate Program
Dpt. of Agricultural Economics
Auburn University, AL 36849

Non Profit Org.
U.S. Postage
PAID
Permit No. 9
Auburn University, AL 36849

REMINDER

Dear Homeowner,

You recently received in the mail a survey about Anniston's environmental risks. Please take the time to fill it out and mail it back to us as soon as you can, using the pre-paid return envelope.

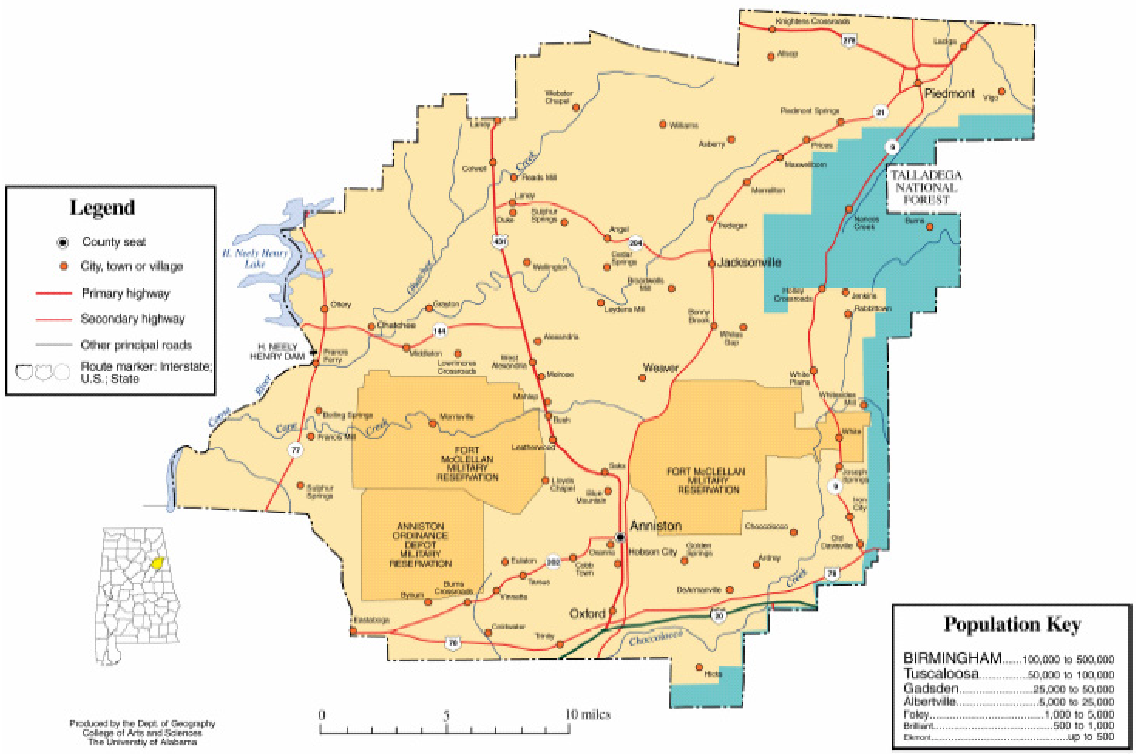
If you have already answered and mailed the survey, please disregard this message.

Thank you for participating in this academic study.

Christophe de Parisot and Sa Ho
Graduate Research Assistants
Auburn University

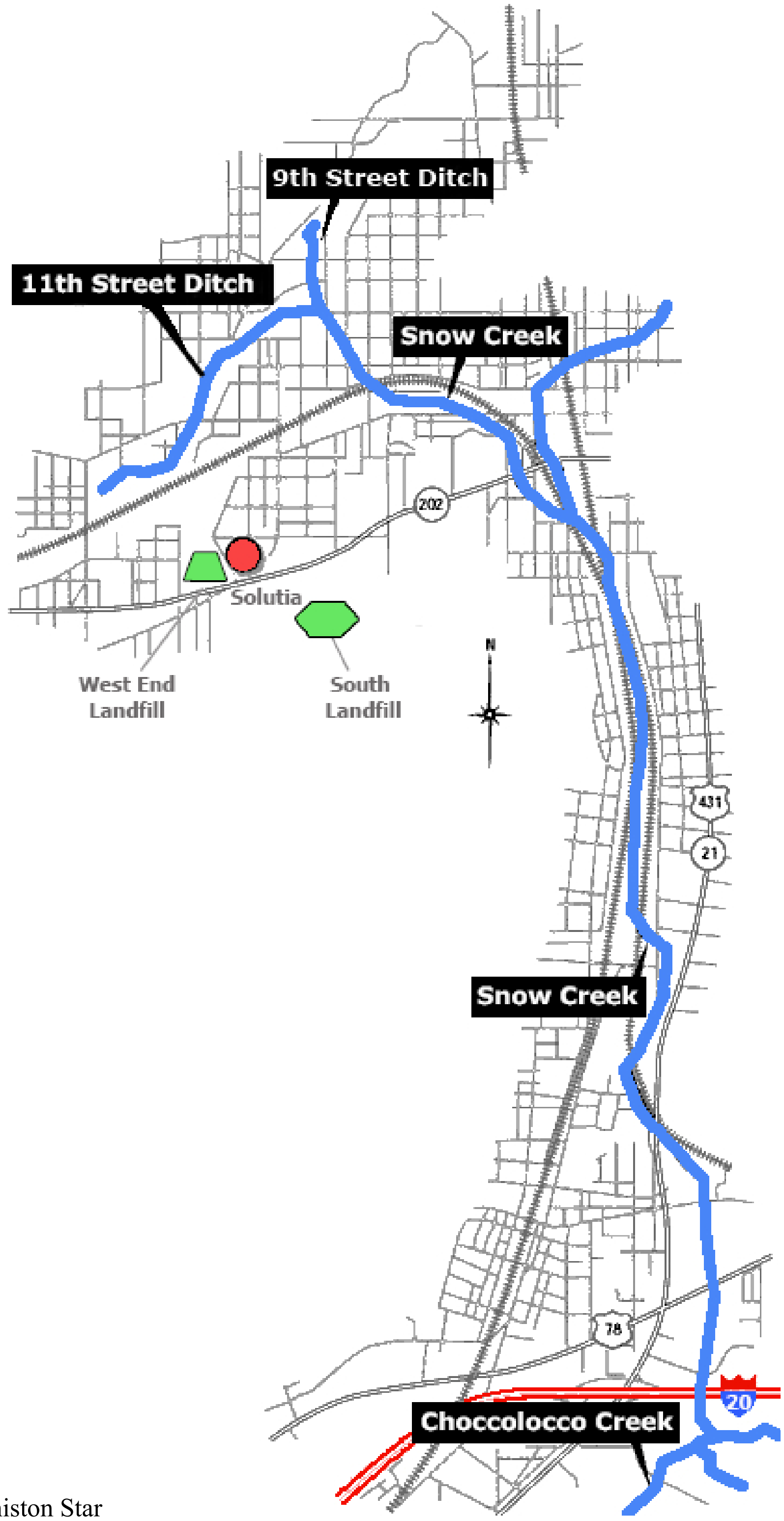
APPENDIX F

MAP OF CALHOUN COUNTY



APPENDIX G

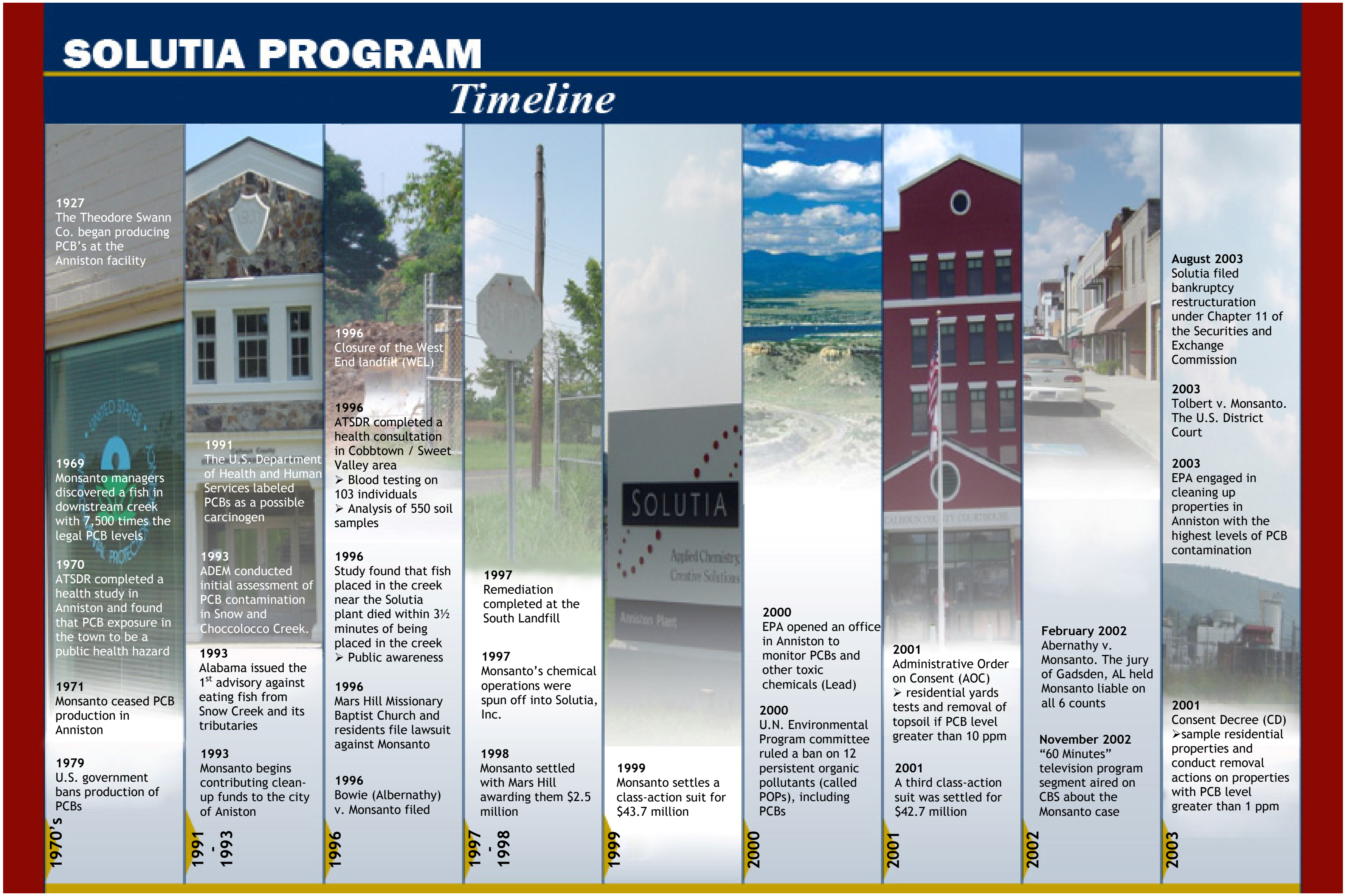
MAP OF SOLUTIA'S PLANT



Source: The Anniston Star

APPENDIX H

SOLUTIA PROGRAM TIMELINE

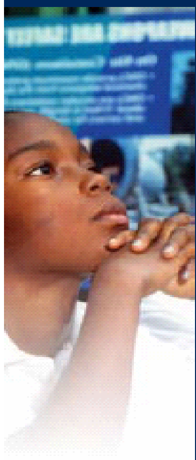

SOLUTIA PROGRAM
Timeline
1970's
1927
The Theodore Swann Co. began producing PCB's at the Anniston facility
1969
Monsanto managers discovered a fish in downstream creek with 7,500 times the legal PCB levels
1970
ATSDR completed a health study in Anniston and found that PCB exposure in the town to be a public health hazard
1971
Monsanto ceased PCB production in Anniston
1979
U.S. government bans production of PCBs
1991 - 1993
1991
The U.S. Department of Health and Human Services labeled PCBs as a possible carcinogen
1993
ADEM conducted initial assessment of PCB contamination in Snow and Choccolocco Creek.
1993
Alabama issued the 1st advisory against eating fish from Snow Creek and its tributaries
1993
Monsanto begins contributing clean-up funds to the city of Aniston
1996
1996
Closure of the West End landfill (WEL)
1996
ATSDR completed a health consultation in Cobbtown / Sweet Valley area
➢ Blood testing on 103 individuals
➢ Analysis of 550 soil samples
1996
Study found that fish placed in the creek near the Solutia plant died within 3½ minutes of being placed in the creek
➢ Public awareness
1996
Mars Hill Missionary Baptist Church and residents file lawsuit against Monsanto
1996
Bowie (Albernathy) v. Monsanto filed
1997 - 1998
1997
Remediation completed at the South Landfill
1997
Monsanto's chemical operations were spun off into Solutia, Inc.
1998
Monsanto settled with Mars Hill awarding them $2.5 million
1999
SOLUTIA
Applied Chemistry, Creative Solutions
Anniston Plant
1999
Monsanto settles a class-action suit for $43.7 million
2000
2000
EPA opened an office in Anniston to monitor PCBs and other toxic chemicals (Lead)
2000
U.N. Environmental Program committee ruled a ban on 12 persistent organic pollutants (called POPs), including PCBs
2001
2001
Administrative Order on Consent (AOC)
➢ residential yards tests and removal of topsoil if PCB level greater than 10 ppm
2001
A third class-action suit was settled for $42.7 million
2002
February 2002
Abernathy v. Monsanto. The jury of Gadsden, AL held Monsanto liable on all 6 counts
November 2002
"60 Minutes" television program segment aired on CBS about the Monsanto case
2003
August 2003
Solutia filed bankruptcy restructuration under Chapter 11 of the Securities and Exchange Commission
2003
Tolbert v. Monsanto. The U.S. District Court
2003
EPA engaged in cleaning up properties in Anniston with the highest levels of PCB contamination
2001
Consent Decree (CD)
➢sample residential properties and conduct removal actions on properties with PCB level greater than 1 ppm

APPENDIX I

ANCDF PROGRAM TIMELINE

PROGRAM *Timeline*

ANCDF



1985
Congress mandated that all chemical weapons be safely disposed
- On-site disposal
- No transportation

June 1992
Families Concerned about Nerve Gas Incineration (FCANGI) organized public hearings on Chemical Weapons incineration

1992

1993
Department of Defense selects incineration as the official destruction method for the Anniston chemical weapons stockpile

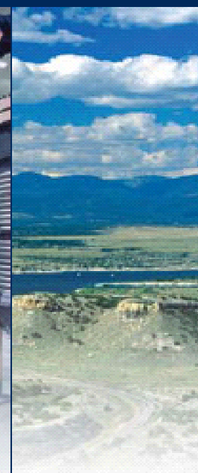
1993
The U.S. signs the United Nations Chemical Weapons Convention treaty

1993

1995
The defense base closure commission voted to close Fort McClelland

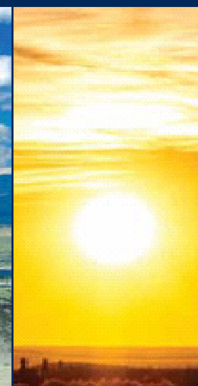
1995
Public Law 103-337 prohibits the transportation of chemical stockpile munitions across sate lines

1995



1996
Public Law 99-145 designates the U.S. Army as the organization responsible for the destruction of the U.S chemical weapons stockpile

1996

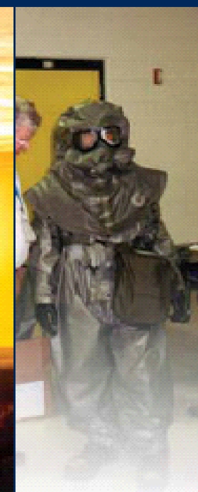


April 1997
The U.S. ratifies the United Nations Chemical Weapons Convention treaty, which directs all member nations to destroy their chemical weapons and production facilities

1997
Construction of the Anniston Chemical Agent Disposal Facility (ANCDF) begins

May 1997
ACWA begins open public participation process, known as the ACWA Dialogue

1997



1998
Chemical Destruction Community Advisory Board established in Anniston

1999
Closure of Fort McClelland

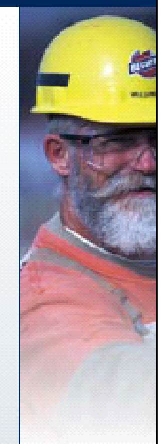
1998 - 1999

2001
ANCDF completed and ready to undergo stringent testing and simulations

2001

August 2003
U.S. Army begins disposing weapons at the Anniston Chemical Disposal Facility

2003



March 2006
ANCDF GB monition disposal operations concluded

2006