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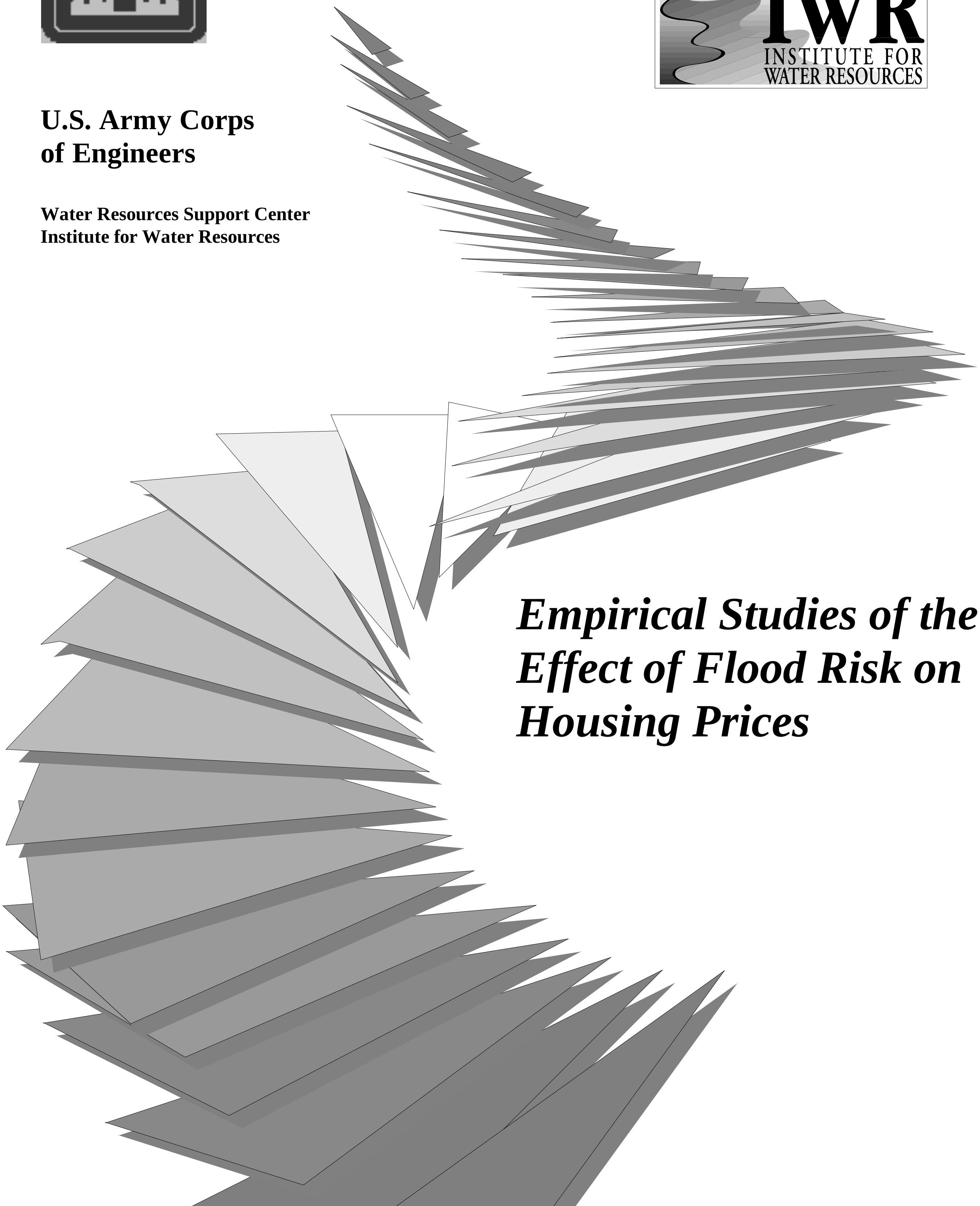

Empirical Studies of the Effect of Flood Risk on Housing Prices

U.S. Army Institute for Water Resources
Policy and Special Studies Programs

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Empirical Studies of the Effect of Flood Risk on Housing Prices

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FEBRUARY 1998 IWR REPORT 98-PS-2

Preface

The motivation for this study stems from criticism of the Corps of Engineers as being biased against non-structural flood damage reduction measures as opposed to structural measures (e.g., Interagency Floodplain Management Review Committee, “Galloway Report”, 1994). One possible source of bias may be the inability of the Corps to economically justify permanent evacuation projects under current evaluation procedures given by the Principles and Guidelines for Water and Related Land Resources Implmentation Studies. This issue and the level of Corps involvement in permanent evacuation projects have become policy questions of increasing importance to the Corps.

During the course of this study, Congress enacted the Water Resources Development Act of 1996 (WRDA 96). Section 202(d) of the Act calls for the Secretary of the Army to identify “impediments that may exist to justifying nonstructural flood control measures as alternatives to structural measures.” The findings of this study will contribute to the full review called for in response to Section 202(d).

Acknowledgements

This study was conducted by Philip Chao, James Floyd and William Holliday of the Policy and Special Studies Division of the Institute of Water Resources (IWR). The report was prepared under the general supervision of Eugene Stakhiv, Chief of the Policy and Special Studies Division of IWR. Harry Shoudy and Jan Rasgus, Policy Development Branch, Policy Review and Analysis Division, Headquarters, Directorate of Civil Works, and Bob Daniel, Chief, Formulation and Evaluation Branch, Planning Division, Headquarters, Directorate of Civil Works, all provided valuable insights during the course of the study.

The authors would like to thank the following Corps of Engineers District staff for providing insight and data: Rebecca Griffith, Fort Worth District; Mitchell Laird, Louisville District; and, James Everman, Larry Workman, and Randy Campbell, Huntington District. We also acknowledge the contribution of the students who have worked on this study: Michael Hollar, Thomas Shoudy, and Renée Selinsky.

EXECUTIVE SUMMARY

The Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) provide that "[R]eduction of flood damages borne by floodplain activities should not be claimed as a benefit of evacuation or relocation because they are already accounted for in the fair market value of floodplain properties." The assumption is that primary flood damages are capitalized into the market value of floodplain properties. Corps guidance for implementing the P&G explains further that "it would be double-counting to also consider the costs of the physical damages."

The principal question this study addresses is: *Can empirical evidence be found that flood damages borne by flood plain activities are or are* <u>*not*</u> *capitalized into the fair market value of floodplain properties?* Until now the Corps has not examined the empirical evidence or reviewed the academic literature to answer this specific question.

Addressing this question is more involved than just comparing the actual price of a floodplain property to a hypothetical, otherwise identical, non-floodplain property. This study defines this difference as the discount for floodplain *location*. The discount for floodplain *location*, however, does not necessarily equate to discount for *primary flood damages*. The location discount represents the net effect of all attributes, positive and negative alike, associated with floodplain location which affect property value. Examples of positive attributes are access to recreational boating and river views. Negative attributes include clean-up costs and loss of income during a flood.

Hedonic price models are used to empirically measure a discount due to primary flood damages, separate from the discount for floodplain location. Hedonic price models describe the contribution of a property attribute to the overall price. The models are empirically assessed with multi-variate regression models where sale price is the dependent variable and the property attributes are the independent variables.

This study reviewed existing academic literature on hedonic price models of the floodplain real estate market. In addition, two hedonic price model cases were studied to answer some of the questions raised in the literature review. The case studies used price data from existing Corps projects in Abilene, Texas and South Frankfort, Kentucky.

Findings

Literature Review

None of the 13 reviewed studies attempted to directly search for evidence of a discount for *primary flood damages*. Most of the studies attempted to detect a discount for location in the floodplain.

- Eight of the studies used a model that employed the variable of location in or out of the 100-year floodplain, without regard to *where* in the 100-year floodplain. Half of the eight studies show a discount for location exists, while half do not. These studies are inconclusive and expected to be so because this model implies that the flood risk is constant across the 100-year floodplain. Flood risk, and therefore any corresponding discount, will vary between properties deep in the floodplain and those just within the 100-year floodplain.
- The capitalized value of flood insurance premiums appears to be discounted from property values. All four studies that examined the effect of flood insurance premiums found property values discounted by the capitalized value of flood insurance premiums if the owners actually purchased

insurance (only about one-fourth actually do). None of these studies distinguished between subsidized and actuarial premiums.

- It is not clear whether consumers are risk averse or risk seeking. One study found that higher-income consumers may be more risk averse than lower-income consumers.
- Two studies addressed the value of positive floodplain attributes. Both found the value of positive attributes to be larger than the value of negative attributes (including the discount for flood damages).
- Three researchers studied property prices in the period following a flood. None found a discount in price over the long-term. One observed a drop in prices followed by a recovery, with the recovery being slower for houses with more frequent flooding.

Case Studies

The literature review suggested several hypotheses to test in the two case studies. However, since the case studies necessarily were limited to sources of available data, not all pertinent issues could be addressed. In particular, the effects of positive attributes could not be measured, and a detailed analysis of flood insurance effects could not be undertaken.

The Abilene data set was analyzed for floodplain location discount by flood frequency zones (in increments finer than the 100-year zone), and for discount due to flood insurance premiums. Since expected damage data was not available, only the discount for floodplain location (and not for primary flood damges) could be analyzed. The results suggest that:

- Lower-priced houses (less than $50,000) deep in the floodplain (within the 25-year floodplain zone) are discounted. For other floodplain zones and price ranges, evidence of discount for location was weaker, and followed no trend.
- Flood insurance subsidies may lessen the floodplain location discount of lower-valued houses.
- Since few higher-priced houses are located in the floodplain, it is unclear whether there is any discount for such properties, or how flood insurance may influence prices on such houses

Although the South Frankfort data set was too small (26 observations) to statistically measure a discount for location, data on expected primary damages were available such that a discount for primary flood damages could be analyzed with the hedonic price model. The results show that pricing behavior varies across the floodplain:

- For the three properties within the 100-year floodplain, the discount for location is proportional to, and roughly the same as, the present worth of expected primary damages.
- For the seven properties outside of the 100-year floodplain, but flooded above the first floor in 1978 (a 150-year flood, sales were between 1989 and 1991), the discount for location varied greatly and, was generally greater than expected primary flood damages.
- Three other properties that only had their basements flooded in 1978 showed no discount for location.

A plausible explanation (no insurance data was available) for the difference between the properties within and outside of the 100-year floodplain is that the three homeowners in the 100-year floodplain were required to have flood insurance, and therefore had a clearer understanding of the potential cost of flooding.

Conclusions

The findings from the literature review and the case studies are insufficient to conclude that flood damages borne by floodplain activities either are or are not capitalized into the fair market value of floodplain properties. The existing studies did not seek and the case studies lacked sufficient data to detect a discount for primary flood damages. In some cases a discount for *location* in the floodplain was not detected. In others, a discount for floodplain location does exist, but varies because of a complex interaction of socio-economic and flood risk factors, such as relative location within the floodplain, flood insurance, flood history and positive floodplain attributes. This complexity limits the possibility of identifying specific conditions for when a discount for primary damages either exists or does not exist.

The variability of these factors across floodplain markets around the country makes the assumption that *all* properties are discounted for primary flood damages unreasonable. The assumption that *all* consumers are fully aware of the flood risk and are risk neutral is not supported by the findings. Although the simplifying assumptions are meant to facilitate project evaluation, in the cases where there is no discount, the benefits of permanent evacuation projects are underestimated.

Although recommendations to improve hedonic price models to detect a discount for primary flood damages are possible based on the findings, it may not be fruitful to pursue such studies further. The foremost issue is including positive and negative attributes of floodplain properties in the hedonic price model to separate the discount due to primary flood damages from the discount due to floodplain location. Identifying and measuring all these floodplain attributes is exceedingly difficult. The researcher is hard pressed to identify all the attributes that property buyers consider when purchasing a floodplain property. Even if all the attributes were identified, they remain to be measured. Since these attributes are not traded explicitly on the market, their value must be indirectly assessed with methods such as hedonic price models or the contingent valuation method. Such studies would be expensive and time-consuming because original data surveys would be required. Even if the attributes were measured, several case studies would have to be conducted to establish general conditions for when there is or is not a discount for primary flood damages. Even if several case studies were conducted, their results still may be inconclusive.

Policy Implications

The findings suggest that greater effort be devoted to analyzing the theoretical and institutional bases for the relevant policies rather than focusing on an empirical basis for justifying the benefits of structural flood protection versus permanent evacuation. The Corps should not expend resources for investigations of the capitalization of flood damages into market values of floodplain properties, either as part of a research project or as part of feasibility studies for flood damage prevention projects.

TABLE OF CONTENTS

Chapter 1 - Introduction 1
1.1. Problem Definition 1
1.2. Study Objective 3
1.3. Study Approach 3

Chapter 2 - Economic Model and Literature Review 5
2.1 Introduction 5
2.2 Hedonic Price Models 6
2.3 Literature Review 9

Chapter 3 - Case Studies 15
3.1 Introduction 15
3.2 Abilene, TX 15
3.3 South Frankfort, KY 24

Chapter 4 - Findings, Conclusions and Policy Implications 31
4.1 Findings 31
4.2 Conclusions 32
4.3 Policy Implications 33

References 35
Appendix A Summaries of Reviewed Literature 37
Appendix B Case Study on Tug Fork, Kentucky and West Virginia 53

LIST OF TABLES

1. Guide to Types of Benefits. 2
2. Corps Permanent Evacuation Projects (USACE, 1994) 3
3. List of Hedonic Price Studies on Impact of Flood Risk on Floodplain Property Values. 10
4. Summary Statistics from Abilene Data. 21
5. Summary of Results by Market Segment from Abilene Data. 23
6. Data for South Frankfort, KY. 26
7. Summary of Results from South Frankfort Model 28

LIST OF FIGURES

1. Number of Observations by Floodplain Zones 17
2. Sale Price by Floodplain Zones 18
3. Area by Floodplain Zones 18
4. House Age by Floodplain Zones 19
5. Sale Price by House Age 20
6. Insurance Premium by Age 20
7. Ratio of ΔP_L to ΔP_D for South Frankfort, KY 29

Chapter 1 - Introduction

1.1. Problem Definition

The Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) provide that "[R]eduction of flood damages borne by floodplain activities should not be claimed as a benefit of evacuation or relocation because they are already accounted for in the fair market value of floodplain properties." The assumption is that primary flood damages are capitalized into the market value of floodplain properties. Corps of Engineers guidance for implementing the P&G explains further that "it would be double-counting to also consider the costs of the physical damages."

The principal question this study addresses is: *Can empirical evidence be found that flood damages are or are not capitalized into the fair market value of floodplain properties?* Until now the Corps has not examined the empirical evidence or reviewed the academic literature to answer this specific question. The report does not address the corollary question, if in fact expected damages are capitalized into market values, as to whether or not claiming primary damages prevented as benefits of permanent evacuation projects would constitute double counting. The study is limited to review and analysis of existing literature and available data only.

Nonstructural flood damage reduction measures are those which "modify damage susceptibility by altering the ways in which people would otherwise occupy and use floodplain lands and waters" as opposed to structural measures which "modify flood behavior" [ER 1105-2-100]. Nonstructural approaches include:

- permanent evacuation and relocation
- floodproofing (including raising the elevation of the structure)
- land use management
- flood warning and preparedness
- flood insurance
- emergency flood fighting and financial relief.

This study focuses on permanent evacuation projects. Evacuation is accomplished in a number of ways. The structure can be acquired and razed, with the occupant seeking alternative housing, either through the open market or in a new flood free building built as part of the flood damage reduction project. Alternatively, the structure itself can be moved to a location outside the floodplain. The move can be done by or for the original occupant, or the building may be re-occupied by someone else.

According to the P&G, there are three types of benefits for flood damage reduction projects: i) inundation damage reduction, ii) intensification (of the existing land use), and iii) location (changes in land use). Table 1, which is reproduced from the P&G, lists the types of benefits by type of project, indicating which types are claimable or not claimable. Primary flood damages (expected annual damages), floodproofing costs reduced and restoration of land value (lowered land values due to the intangible costs of flood hazard) may **not** be claimed as benefits of permanent evacuation projects.[1]

Table 1 Guide to Types of Benefits [P&G, Table 2.4.14, p. 38].

Type of Benefit	Structural	Floodproofing	Evacuation
Inundation:			
Incidental flood damages	Claimable	Claimable	Claimable
Primary flood damages	Claimable	Claimable	Not claimable
Floodproofing costs reduced	Claimable	Not claimable	Not claimable
Reduction in insurance overhead	Claimable	Claimable	Claimable
Restoration of land value	Claimable	Claimable	Not claimable
Intensification	Claimable	Claimable	Not claimable
Location:			
Difference in use	Claimable	Claimable	Not claimable
New use	Not claimable	Not claimable	Claimable
Encumbered title	Not claimable	Not claimable	Claimable
Open space	Not claimable	Not claimable	Claimable

Partly because primary flood damages are excluded as a benefit for evacuation projects, such projects are seldom economically justified based on P&G procedures. The Corps has built hundreds of structural FDP projects, but, as of 1994, had completed only six projects using purely evacuation or using evacuation with other nonstructural measures (Table 2).[2] The Corps has also, on occasion, accomplished permanent evacuation as part of structural projects. The scarcity of permanent evacuation projects has been cited as evidence of a bias against them.

[1] The P&G says that Table 1 applies generally, but its application may vary in specific cases (p. 38).

[2] Some of these projects (for example, Prairie du Chien, completed in 1984) were developed prior to promulgation of the P&G in 1983. Prior to that time there was no exclusion of primary flood damages as a project benefit.

Table 2 Corps Permanent Evacuation Projects (USACE, 1994) *

Project Name	State	Project Description	Date Construction Completed	Cost ($)
Prairie du Chien	WI	Acquired and removed 122 houses, 2 commercial structures	1984	4,600,000
Wilson Branch, Sumter Co.	SC	Relocated 6 homes	1984	284,000
Sope & Proctor Creek, Marietta	GA	Acquired and relocated 13 homes	1986	1,100,000
Murder Creek, East Brewton	AL	Acquired 19 commercial properties, 1 floodproofed	1985	1,179,000
Proctor Creek, Marietta	GA	Acquired and relocated 32 homes	1990	1,100,000
Allenville	AZ	Acquired 54 houses, built replacements outside floodplain	1981	4,840,000

* Note: Does not include projects in the Tug Fork and Upper Cumberland Basins, WV and KY, which are being developed under special legislation which waives economic justification

1.2. Study Objective

The objective of this study is limited to a search for evidence that expected annual flood damages borne by flood plain activities are or are not capitalized into the fair market value of floodplain properties. The secondary objective is to identify the conditions under which the discount in market value does not exist, such that at least in those cases it may be justifiable to claim primary flood damages as a benefit in evaluating permanent evacuation projects.

These objectives are approached empirically. A theoretical approach, which would examine the economic rationale embodied in the P&G, is not used here, as the theory and assumptions of the P&G will be not be challenged directly. If the expected discount cannot be found or is empirically small either in general (applicable in all cases), or under specific, restricted conditions, then a basis for claiming primary damage benefits would have been found. If restricted, primary flood damage benefits could be claimed where those specific conditions exist.

1.3. Study Approach

The first phase of this study reviewed the economic theory underpinning the evaluation of evacuation projects, focusing on hedonic price models, a technique used to implicitly assess the value of property attributes. This technique is employed in a number of studies of the effect of floodplain location on property values. A review of economic theory of the floodplain property market opens Chapter 2.

Chapter 2 continues with the next phase, a literature review of studies found that address the effect of flood risk on property values. It was initially anticipated that the published studies would provide an adequate basis for meeting the objectives of this study. However, the evidence of whether property values are discounted due to flood risk was inconclusive. Therefore, the final phase proceeded to develop hedonic models based on primary data obtained from related studies ai Abilene, Texas and South Frankfort, Kentucky. These case studies are presented in Chapter 3.

The findings, conclusions, and recommendations are presented in Chapter 4.

Chapter 2 - Economic Model and Literature Review

The first section of this chapter introduces the economic model that explains why a discount for primary flood damages should be expected. The subsequent section addresses the most widely used method to empirically detect a flood risk discount - hedonic price models. The chapter concludes with a section that reviews existing hedonic price model studies of flood risk discount.

2.1 Economic Model

Project benefits result from increases in consumer's and producer's surpluses due to the presence of the project. In the case of flood damage reduction projects, project benefits are due to decreases in flood damage to property within the project area. The P&G, which guides the Corps' use of benefit-cost analysis to evaluate projects, assumes a partial equilibrium market model for expecting a discount in the value of a floodplain property. Neither the P&G nor the Corps' implementing guidance specifically discuss the theory of this economic model. However, McDonald *et al*., [1987] explain the model as follows:

> "The estimation of willingness to pay for a reduction in flooding hazard is based on the relationship between housing price differentials and rational consumer behavior. The consumer will make a location choice which maximizes expected utility. The potential loss associated with flooding hazard forces the consumer to incorporate the hazard into this choice. The rational consumer will be willing to pay an amount, dependent on the perceived loss and its probability of occurring, to locate in an area where the hazard does not exist (or exists with a reduced probability of occurrence). Conversely, the rational consumer will locate within the hazard area only if they are compensated for accepting the potential loss. The willingness to pay (or compensation) should be capitalized into the prices of housing with respect to different probabilities of flooding. Further, if insurance is available, the housing price differentials should reflect the insurance premium differentials which exist for the various probabilities of a flood occurring."

However, market dynamics are not so simple. Flood damage risk is but one of many factors that determine property price decisions. Attitudes and perceptions of risk, knowledge of flood risk, expectation of government disaster relief, including recovery assistance, and the rules of the National Flood Insurance Program (NFIP) add to the complexity of market dynamics. Prices of floodplain properties are also affected by other attributes unique to the floodplain. The condition of properties may be poor because post-flood repairs fall short of full restoration, especially for properties subject to frequent flooding. The development of the floodplain may be unique from the rest of the community thus making it a different market. Location in the floodplain also offers benefits (such as access to the water and nice views) which are difficult to separate from flood risk disbenefits when assessing property price decisions.

Because of these complicating factors, there is some question as to whether the P&G assumption that properties are discounted for primary flood damages is correct. In fact the existence of a discount for primary flood damages has never been empirically demonstrated. The methods to empirically measure the contribution of an attribute to the value of a property include hedonic price models and contingent valuation techniques. The study focuses on hedonic price models because they are more effective in separating out non-mutually exclusive factors.

2.2 Hedonic Price Models

The price for a property depends upon the attributes of the property. Mathematically this relationship can be written as:

$$P = f(a_1, a_2, \cdots, a_n) \qquad \textbf{(1)}$$

where P is the price of the property, $f(\cdot)$ is an arbitrary function, and a_i are the attributes of the property. Attributes include physical aspects of the property (e.g., size, age, and number of rooms) and locational attributes (e.g., school district and proximity to business district). A hedonic price model measures the contribution of each attribute to the value of the property. Mathematically the hedonic price is the partial derivative with respect to the attribute:

$$HedonicPrice = \frac{\partial P}{\partial a_i} \qquad \textbf{(2)}$$

The practical approach to empirically calculate a hedonic price is to fit a multi-variate ordinary least squares regression model:

$$P = c_0 + c_1 a_1 + c_2 a_2 + \cdots + c_n a_n \qquad \textbf{(3)}$$

where c_i is the regression coefficient or hedonic price for attribute a_i. Equation 3 shows a linear relationship between price and the attributes, but alternative functional forms (e.g., log-linear and semilog) may be assumed by transforming the variables.

There are three fundamental steps in applying this regression model:

1) <u>Choosing the appropriate variables to represent property attributes, including flood risk.</u> All relevant attributes must be represented as variables in the regression model. If attributes are not represented in the model, changes in price cannot be attributed solely to specific variables unless there is good reason to believe the omitted attributes are uncorrelated with the specific variable. For example, proximity to a shopping district should have little correlation to whether a property owner has or has not flood insurance. Even if all the attributes are identified, a measurable variable that represents that attribute must be identified. For example, the presence of a basement in a house can be represented by a dummy variable, i.e., the variable takes the value of zero if there is no basement, and one if there is one. On the other hand, a representative and measurable variable for the attribute of a nice view of a river is not easily identified.

2) <u>Determining a suitable functional form to represent the relationship between price and the attributes.</u> Because price is determined by the market, the form of the function $f(\cdot)$ in Equation 1 and therefore the hedonic price depends upon the interaction of consumer demand function, producer supply function and

income constraint [Rosen 1974]. As a result, $f(\cdot)$ cannot be determined theoretically. It is also difficult to obtain empirical measures of these functions to generate $f(\cdot)$ from a general equilibrium model. Halvorsen and Pollakowski [1981] point out that because the form of $f(\cdot)$ cannot be specified, models based on linear or log-linear regressions, which are the most commonly used forms, impose too restrictive or incorrect assumptions upon the economic model.[3] On the other hand, the coefficients of linear or log-linear models are the easiest to interpret. A well-conducted study should explore a variety of functional forms and properly interpret the results given limits of each functional form.

3) <u>Obtaining suitable data.</u> Identifying appropriate variables goes hand-in-hand with obtaining suitable data. A measurable variable may be identified, but it may never have been actually measured in the field. Data may be drawn from existing databases or gathered from surveys. Data collection is limited by time and money. For the case of real estate, much data is available, specifically from the Multiple Listing Service (MLS). However, most attributes related to flood risk are not available and the research must rely on combining typical MLS data with original surveys.

In forming hedonic price models to assess a discount for primary flood damages, an obvious, simple variable to choose is a dummy variable a_1 ($a_1 = 1$ for a property in the floodplain and $a_1 = 0$ for one outside of the floodplain) to represent location in the floodplain. Let the price differential between otherwise identical properties be defined as:

$$\Delta P_L = P_{out} - P_{in} = f(a_1 = 0, a_2, ..., a_n) - f(a_1 = 1, a_2, ..., a_n) \qquad \textbf{(4)}$$

where P_{out} is the price of a property not subject to flood risk and P_{in} is the price of an otherwise identical property subject to flood risk. Being in or out of the floodplain is equivalent to being exposed or not exposed to flood risk. It does not reflect degree of risk. An alternative to a dummy variable, which better captures the degree of risk, is to use flood frequency to the first floor elevation as the variable.[4]

In either case, ΔP_L is the hedonic price (discount) for floodplain *location*. ΔP_L is not, however, the same as the discount for the capitalized value of primary flood damages, defined as ΔP_D. A change in property value according to floodplain location is due to primary flood damages as well as other negative and positive floodplain attributes. The negative attributes include monetary (e.g., anticipated loss of income, temporary evacuation costs, and condition of houses) and non-monetary damages (e.g., emotional and nuisance factors,

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[3] Halvorsen and Pollakowski promote the use of quadratic Box-Cox regression models to avoid this problem of mis-specification. Box-Cox regression models are generalized regression models, which, based on a likelihood ratio test, will choose an appropriate functional form. The functional forms include linear, log-linear and various quadratic forms.

[4] A note on function form. Although the functional form of a hedonic price model cannot be identified a priori, the coefficients from a log-linear form are easier to interpret than those from a linear model. A log-linear model with dummy variables for location in the floodplain yields the <u>percentage</u> change in price due to floodplain location, rather than the <u>absolute</u> change given by a linear model. If the range of prices in the data set is large, then a non-sensical result can result if the floodplain location discount calculated from a linear model is greater than the absolute value of the property.

knowledge of or experience with flooding, potential for government flood assistance, effectiveness of floodplain regulations and risk attitudes). Positive attributes include recreational and aesthetic values. ΔP_L, as well as some of the other negative and positive attributes vary, in value across the floodplain. For example, access to waterborne recreation is much greater if a property abuts the river.

To distinguish the floodplain attributes let:

$$P_L \qquad P_D + \sum_{i=1}^{n} \; P_i \qquad \sum_{j=1}^{m} \; P_j \qquad \textbf{(5)}$$

where ΔP_i are the hedonic prices from negative floodplain attributes (other than primary flood damages), and ΔP_j are the hedonic prices of positive floodplain attributes.

Ideally, Equation 5 should be solved for ΔP_D. ΔP_D should be compared to the present worth of the expected annual flood damage. The hedonic price model should therefore include variables that represent all relevant floodplain attributes. The choice of additional variables, however, is limited because of data availability and because certain attributes may be unmeasurable or difficult to measure in terms of dollars. If variables are missing, which is likely to be the case, the magnitude of ΔP_D is uncertain. Furthermore, if the missing variables are correlated with floodplain location (i.e., vary across the floodplain), then ΔP_D cannot be attributed solely to primary flood damages.

Even if the ΔP_i's and ΔP_j's are not measured, measurement of ΔP_L is still insightful because, if it is shown to be greater than zero, then the sum of ΔP_D and the hedonic prices for other negative attributes, ΔP_i, is at least as large as that for the positive attributes, ΔP_j. This result would imply that there is a discount for primary flood damages, although the magnitude of the discount would be unknown. On the other hand, if ΔP_L is less than or equal to zero, then it *cannot* be proven that ΔP_D is zero. As will be shown, the majority of the existing academic studies do not attempt to separate the negative and positive attributes of floodplain location. They seek only to measure a discount for floodplain location (i.e., ΔP_L), and without regard to position within the floodplain.

Measuring ΔP_D is further complicated by flood insurance. Flood insurance changes the risk that the consumer must consider [Krutilla 1966, Thampapillai and Musgrave 1986]. The economic model predicts that a consumer should discount for the present worth value of their annual flood insurance premium. Since the monetary risk of flooding is reduced, the intangible costs, ΔP_i, should also be reduced. However, the National Flood Insurance Program (NFIP) and its effects upon property values is complex such that the present worth of annual insurance premiums is substantially different from, and less than, ΔP_D. NFIP requires a minimum standard deductible, a minimum premium, and limits on maximum coverage. Actuarial insurance, which is limited to $150,000 coverage, is only available for houses built after Flood Insurance Rate Maps (FIRM) have been established for a community.[5] Houses built before a FIRM is established for a community are eligible for subsidized insurance (limited to $35,000 of subsidized coverage and an additional $115,000 limit of actuarial coverage). Since NFIP requires flood plain zoning regulations to limit post-FIRM development in the floodplain, most floodplain properties are pre-existing and eligible for subsidized

[5] FIRMs are maps which define floodplain zones. The zones determine the type and level of insurance available. FIRMs distinguish to the level of 100-year flood zones, but not to 10, 25 or 50-year flood zones.

insurance.[6] Incorporating the effects of NFIP within the hedonic price model therefore requires more than just annual premiums. To distinguish between subsidized and actuarial premiums, the hedonic model should include variables for age of house and date of last sale. Hedonic models should be formed separately for properties less than $35,000, between $35,000 and $115,000 and greater than $115,000 to account for the subsidized coverage limits.

Finally, expectations of recovery assistance are believed to have a substantial influence on risk perceptions and attitudes.[7] These effects are even more complex and difficult to measure than the effects of flood insurance. Two hypotheses can be made. First, property owners are ignorant of flood risk and therefore do not discount. When a flood hits, they determinedly demand flood relief assistance. Second, property owners are aware of flood risk, but do not discount because they expect flood relief assistance. Either hypothesis is difficult to test with a hedonic price model.

2.3 Literature Review

The literature review covers existing studies that attempt to measure a discount for floodplain properties. The studies are listed in Table 3 and each is summarized in Appendix A. This set of studies is fairly comprehensive. Most use hedonic price modeling, while some use difference in means to measure a discount. The hedonic price model studies assume either a linear or a log-linear function form. All but one attempted to measure ΔP_L. Only Muckleston, and Speyrer and Ragas attempted to measure the hedonic price of positive floodplain attributes. A few other studies were not reviewed in depth because they had poorly specified models, lacked sufficient data, or had different objectives.

Studies with floodplain location as an independent variable

A dummy variable representing whether a property was in or out of the 100-year floodplain zone has been used in several hedonic price studies [Bialaszewski and Newsome 1990, McDonald *et al.* 1987, Muckleston 1983, Shilling, Simans and Benjamin 1989, Skantz and Strickland 1987, Speyrer and Ragas 1991, and Zimmerman 1979]. Babcock and Mitchell [1980] defined a dummy variable for in and out of high and low risk flood zones.[8] Similarly Donnelly [1989] created a variable that was the product of a dummy variable for floodplain location times property tax. These researchers chose the 100-year floodplain zone rather than a finer increment of zones because 100-year floodplain zone data are readily available from flood insurance rate maps (FIRMs). In essence, all these models determine if the mean value of properties in and out of the 100-year floodplain zone is statistically different. Four of the eight studies show a discount for *location* exists, while the others do not. These results are inconclusive, and are expected to be so, because the models imply ΔP_L is constant across the floodplain. ΔP_L should increase with increasing flood hazard.

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[6] A further complication is that, at least until 1994, mortgagors were not required to maintain flood insurance coverage for the full term of the mortgage, or the life of the property.

[7] For example, grants and low interest loans for rebuilding and repairs.

[8] The case study by Babcock and Mitchell was located in Canada and therefore the 100-year flood zone as used in the U.S. by FEMA was not defined. They defined the high and low risk zones, respectively, as the area from the river to the maximum observed flood line and as the area from the high-risk zone to the expected flood line associated with a storm of the magnitude of Hurricane Hazel which traversed Southern Ontario in October 1954. The flood frequency of these zones is undefined in their paper.

Table 3 List of hedonic price studies on impact of flood risk on floodplain property values. "Y" and "N" denote, respectively, that the variable was found to be or not to be statistically significant.

Study	Independent Variables					Other Independent Variables
	Floodplain† (in/out)	Flood Frequency	Sale (Before/ After) Flood	Insurance (yes/no)	Insurance Premium,$/yr	
Babcock and Mitchell, 1980	N		N			
Bialaszewski and Newsome, 1990	N					
Donnelly, 1989						Floodplain x Assessed Tax [Y]
Griffith, 1994	Y	Y		Y	Y	Lending bank required flood insurance [Y]
Holway and Burby, 1990						Zoning [N] Flood history, # of floods in last 5 yrs. [N] Structural Protection [N]
MacDonald, Murdoch, White, 1987	Y					
Muckleston, 1983						Pre or post zoning regulation [N]
Shilling, Simans, Benjamin, 1989	Y					
Skantz and Strickland, 1987	N		N			Sale after insurance rate increase [Y]
Speyrer and Ragas, 1991	Y					Flood insurance index [Y]
Thunberg and Shabman, 1991				Y		Emotion and social impacts of floods [Y]
Tobin and Montz, 1994			Y			Personal experience with flood [N] Flood depth [N]
Zimmerman, 1979	N					

† "Floodplain" indicates that a property is within or outside of the 100-year floodplain zone (a 0/1 dummy variable).

Griffith [1994] recognized this variability and formed a hedonic price model with flood frequency as an independent variable. She tested both linear and log-linear models. The t-statistic for the coefficient for flood frequency was significant to 95% for the log-linear models, but the results are unreliable, since outliers were not appropriately removed. Griffith hypothesizes that ΔP_L may not increase linearly over the floodplain and that it is possible only that those properties deep in the floodplain are discounted. The Abilene case study in Chapter 3 (which draws from the same data set used by Griffith) tests this hypothesis. The case study uses dummy variables for smaller increments of floodplain frequency zones (100, 50, 25 and 10-year zones) rather than the actual flood frequency value as an independent variable because using the actual frequency value as the variable assumes the discount is proportional to the frequency.

Floodplain topography also has been included in hedonic price models. Tobin and Montz [1994] found flood depth was not a statistically significant factor. Depth should not have strong explanatory power, since it alone neither reflects the frequency of the flood depth nor the intrinsic value of the property.

Flood insurance's influence upon ΔP_D

Few researchers have included flood insurance premium as an independent variable in hedonic price models, let alone specify the hedonic model to account for the complexity of NFIP. Shilling, Simans and Benjamin [1989] created a log-linear hedonic price model with insurance premium as an independent variable. The coefficient for this variable was significant and negative as hypothesized. Since they did not report descriptive statistics, it is not possible to determine how much of the insurance was subsidized. Thunberg and Shabman [1991] formed a log-linear model with a dummy variable representing whether a property owner had or did not have flood insurance, and a dependent variable of willingness-to-pay for flood control (rather than property value). Their data were based on contingent valuation. They found the coefficient for the flood insurance dummy variable to be significant and of the right sign. Based on this result, they suggest that people are willing to purchase flood insurance over flood control. Griffith [1994] found that property values dropped when the requirement to purchase insurance was enforced by the lending institution of the mortgage.

Skantz and Strickland [1987] found with a log-linear model that "when insurance rates increased markedly [400%] approximately one year later [after a flood], the higher rates are capitalized into home values and prices fall."[9] Prior to the flood, insurance rates were so highly subsidized that the average annual premium was only $14 for properties in the flooded neighborhood in question.

Speyrer and Ragas [1991] created a spline regression model that included an insurance cost index (ratio of unit premium/unit price divided by ratio of average premium/average price). A spline regression model addresses the spatial distribution of property values.[10] Through a two-dimensional Cartesian plot of the spline model, they identified neighborhoods where house prices were lower due to flood risk. They suggest that the discount was due primarily to capitalization of insurance premiums, but also due to the inconvenience of flooding (intangible risk averse costs).

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[9] The marked increase in insurance rates must be assumed to be an atypical case.

[10] A spline regression uses "Bezier Spline" curves to capture locational variation. The regression equation takes the form of a third-order polynomial which is how a spline curve can be defined. The location of each property is denoted by Cartesian coordinates. The purpose of spline regression is to generate a surface which shows where property values are depressed due to some locational factor such as flood risk.

In summary, these studies generally show insurance premiums are capitalized into property values. However, these studies cannot be used as evidence to support the assumption that there is a discount for primary flood damages. The first reason is only one of them distinguishes between subsidized and actuarial rates. The second reason, and the more important reason, is NFIP participation rates are low nationally, about 25% in 1990 [Holway and Burby 1990]. Further evidence would need to be gathered to demonstrate whether the remaining uninsured floodplain properties discount for flood risk.

The effect of risk attitudes upon ΔP_L

A risk averse person would discount more than ΔP_D because of the anxiety and/or inconvenience caused by flood hazard. Although information on flood risk may be available to consumers, Thunberg and Shabman [1991], and Griffith [1994] have hypothesized that consumers may have a difficult time assimilating the effect of rare events into their willingness-to-pay. As a result ΔP_L may be significant for frequently flooded areas, on the order of 10 to 25 year flood frequencies, while ΔP_L may be small for rarer flood events. The South Frankfort case study in Chapter 3, which has data on actual sales, expected flood damage, and flood frequency, examines this hypothesis.

MacDonald *et al.* [1987] found evidence that consumers are risk averse toward flood risk. They carried out a contingent valuation study and found that ΔP_L was greater than the present worth of actuarial insurance premiums, which generally is equivalent to ΔP_D. In other words, they concluded that consumers place a cost for flood risk aside from actual expected damages. Their study was based on contingent valuation rather than actual house sales. They also found risk averse attitudes were more pronounced among average to above average priced properties. They hypothesized that owners of above average priced homes value security from floods. Meanwhile, some owners of below average priced homes may be less risk averse, because they may perceive that repairs they can make after a flood event will enhance the value of their homes beyond what it was before the flood. The effect of income levels upon flood risk attitude also is discussed in the Abilene case study in Chapter 3. In addition, Thunberg and Shabman [1991] found with a hedonic price model evidence that individuals are willing to pay for flood protection to reduce expected flood damages and to reduce anxiety and community disruption.

Measuring positive floodplain attributes

Muckleston [1983] hypothesized that the value consumers place on riverine amenities may outweigh that for flood hazard disamenities. With a hedonic model that included proximity to the river as a variable, he found property prices rose faster for riverside properties (after the water quality improved in the river) than for other floodplain properties even as floodplain regulations and the NFIP were making the flood hazard more apparent to consumers.

Speyrer and Ragas [1991] used proximity to a lake as a proxy for lacustrine amenities. Proximity to a lake was found to be a positive amenity and larger than the discount due to flood risk. Proximity is a useful measure, but it is limited in that different consumers may value riverine amenities differently.

The effect of floodplain regulations upon ΔP_L

Holway and Burby [1990] examined the effect of floodplain regulations upon undeveloped land values for nine communities across the country. They found land values decrease under zoning regulations requiring low density development and for flood proofing construction requirements. They warn that zoning regulations will lower land values, only if local authorities administer them well.

Muckleston [1983] found tentative evidence that floodplain regulations do not affect the value of developed property. He found that riverfront properties increased in value even after floodplain regulations were in place. He hypothesized that riverine amenities, which improved after the water quality of the river improved, increase property values more than floodplain regulations decrease them.

Personal experience with floods and ΔP_L

Recent homeowner experience with floods has also been hypothesized as a discounting factor. Such studies measure ΔP_L, the discount for location in the flood plain. Skantz and Strickland [1987], and Babcock and Mitchell [1980] looked at house sales before and after a flood. Neither study found statistically significant differences in house prices. Tobin and Montz [1994] hypothesized and found evidence that prices fall after a flood, but soon recover. They found, for a community with frequent but less severe flooding, prices take longer to recover. Nevertheless, Tobin and Montz's results do not support the existence of long-term capitalization of expected flood damage into housing prices.

Summary and discussion of factors that affect ΔP_D

The important question of whether a discount due to primary flood damage exists could not be answered from the literature review. Most of the existing studies do not attempt to separate the discount due to primary flood damage from the more general discount due to floodplain location. Even then, the studies on a discount for floodplain location, ΔP_L, are inconclusive. Nevertheless the literature review revealed the complexity of hedonic prices for floodplain properties.

- Eight of the studies used a model that employed the dummy variable of location in or out of the 100-year floodplain. Half of the studies show a discount for location (in the floodplain) exists, and half do not. These studies are inconclusive and expected to be so because this model implies that the flood risk is constant across the 100-year floodplain. Flood risk, and therefore any corresponding discount, will vary among properties deep in the floodplain, say within the 25-year floodplain, and those just within the 100-year floodplain. The case studies in Chapter 3 model floodplain location with finer increments of floodplain zones.

- Four studies examined the effect of flood insurance premiums. All four found property values discounted by the capitalized value of flood insurance premiums (only where premiums actually are paid). However, none of these studies accounted for the complexity of the NFIP, in particular the relative effects of subsidized versus actuarial rates. Only about a fourth of property owners purchase flood insurance, so it cannot be assumed that all property owners discount for primary flood damages.

- It is not clear whether consumers are risk averse or risk seeking. Two studies hypothesized that consumers may have a difficult time assimilating the effect of rare events into their willingness-to-pay. A contingent valuation study suggests that higher-income consumers may be more risk averse than lower-income consumers.

- The value of positive floodplain attributes was addressed in two studies. Both found the value of positive attributes, ΔPj's, to be larger than the flood hazard disamenities, ΔP_D and ΔP_i's. No academic studies were found that have data sufficient to separate the discount for flood risk disamenities from riverine amenities. Negative floodplain attributes (e.g., indirect costs, trauma, temporary dislocation and inconvenience) may be even more difficult to measure in dollar terms than positive floodplain attributes.

- Three sets of researchers studied property prices in the period following a flood. None found a discount in price over the long-term. One study observed a drop in prices followed by a recovery, with the recovery being slower for houses with more frequent flooding. None of these studies included data on the physical condition of houses, all of which were damaged and then repaired.

These results show that no existing study comes close to the complex modeling needed to measure a discount for primary flood damages let alone one for floodplain location. The results, however, suggest ways to improve hedonic price models and understanding of the value of floodplain properties. In particular, such studies should address floodplain location at finer increments than the 100-year flood zone, such as the 10, 25, and 50-year flood zones. Hedonic price models based on floodplain location also would need to include positive and negative attributes that may be correlated with floodplain location. If these other attributes were not included, then ΔP_D could not be measured. The impact of NFIP upon ΔP_L and ΔP_D could be addressed with a carefully formed model and sufficient data on insurance premiums, type of insurance coverage, and age of house. History of flooding or personal experience with flooding would also be required. Last, because utility functions may vary among income groups, models should be formed from relatively homogeneous markets.

Nevertheless improving hedonic price models to detect ΔP_D would be a considerable task. Data on floodplain attributes is limited. Multiple Listing Service databases do not generally include floodplain attributes, such as access to water and floodproofing. Much of the data is subjective or unmeasurable. For example, in measuring nice views of the river, survey takers would have to develop some type of cardinal scale of what are bad, average and good views of the river. It is unlikely that such a subjective scale would be applied consistently across studies let alone within a single study. All the floodplain attributes must be included in the hedonic model. If variables are missing, the magnitude of ΔP_D will be uncertain. Furthermore, if the missing variables are correlated with floodplain location (i.e., vary across the floodplain), then ΔP_D cannot be attributed solely to primary flood damages. It seems unlikely that survey takers and study managers would be able to identify all the floodplain attributes that property owners considered in their purchasing decisions.

Chapter 3 - Case Studies

3.1 Introduction

The literature review failed to disclose whether a discount for primary flood damages either exists or does not exist. However, the understanding gained from analyzing the literature provided a framework to specifically evaluate primary flood damages. Two case studies were analyzed for evidence of discounting for primary flood damages: i) Abilene, Texas and ii) South Frankfort, Kentucky. A third case, discussed in Appendix B, was analyzed for Pike County, Kentucky on the Tug Fork River, which forms the West Virginia and Kentucky border. This case study proved inconclusive because the price data were derived from appraisals rather than actual sales.[11]

As noted in Chapter 2, data indicating simply whether a house is in or out of the 100-year flood frequency zone are insufficient to measure the ΔP_L, let alone ΔP_D. The case studies include data on finer increments of flood frequency zones. The Abilene case study also examines the effect of flood insurance and of income upon ΔP_L. The South Frankfort case study includes data on not only flood frequency but more importantly expected annual flood damages. With the damage data, ΔP_L could be compared to the present worth of expected annual flood damage, PW(E[FD]).

As will be discussed, even with these case studies, it is not possible to make broad generalizations. These case studies offer a better understanding of hedonic price modeling for flood risk. Nevertheless, it is extremely difficult to gather sufficient and comprehensive sets of data and to form effective hedonic price models to detect ΔP_D. Because the data were not gathered specifically for this study, they omit important information that prevent effective modeling of all the relevant property attributes. In particular, the separation of positive floodplain attributes from negative floodplain attributes, and the effect of subsidized insurance could not be addressed in these case studies.

3.2 Abilene, Texas

Description of the Area and Data Sources

Abilene was selected as a case study because it had been the subject of a prior hedonic modeling study and data appropriate to this study were available. Griffith [1994], in a study entitled "The Impact of Mandatory Purchase Requirements for Flood Insurance on Real Estate Markets," compiled data on residential sales prices, house characteristics including floodplain location by frequency zone, flood insurance, and other traits significant to the real estate market. Griffith made the data available for this study.

Abilene is located in north central Texas. The population in 1990 was approximately 105,000. Elm Creek and three of its tributaries, Little Elm Creek, Cat Claw Creek, and Cedar Creek, flow through the city.

[11] The appraisers did not consider explicitly floodplain location when assigning values to the structures. Two other issues make Pike County less than ideal for hedonic price modeling. First, Pike County is a unique market with many of residences remaining within the same family for many generations, such that sales may not reflect true market values. Second, because of the topography of Tug Fork, the market is not fully competitive in that there are few comparable housing alternatives outside of the floodplain. A further request to Corps Districts and Divisions for data for case study analysis found extremely limited cases that have meaningful data. The available data were found to be lacking in one aspect or another.

These streams are perched, that is, the stream banks are at a higher elevation than the surrounding floodplain. This is an unusual condition under which flooding, when it occurs, becomes widespread, albeit shallow. A number of destructive floods have occurred in the watershed. The flood of record occurred in 1932. The most destructive flood event of the 13 that occurred between 1974 and 1986 came in October 1981. Abilene has participated in the regular phase of the NFIP since 1971, with the effective rate map dated 1984. The Corps of Engineers completed a flood control study of the area in 1990.

Griffith selected Abilene because critical data were available. Due to the high cost of collecting the necessary data, she sought a location in which both a FEMA sponsored floodplain delineation and a Corps flood control study had been recently completed. Additionally, the geographic isolation of Abilene meant the boundaries of the real estate market could be identified.

Griffith obtained real estate data from the Abilene Board of Realtors. For sales made between April 1988 and March 1993, the sales price and house characteristics such as date of closing, square footage, Realtors' neighborhood code, and type of financing were collected. The Flood Insurance Administration (FIA) provided a list identifying each residential flood insurance policy in effect in the City of Abilene. Data obtained from the Corps included flood frequencies, specifically location within zones of probabilities of flooding. The 1990 Census of Population was consulted for data on neighborhood demographic characteristics. The final data set contained approximately 4700 observations. Griffith calculated her results from about 3700 observations because not all variables were available for all observations.

Exploration of the Data

Prior to formulation of hedonic regression models, trends in the data which might guide model development were explored. Trends relating the following data fields were examined:

- sale price (dollars)
- house area (square feet)
- age of house (in 1993) or year of construction (years)
- percent of high school graduates in the neighborhood (percent)
- flood insurance premium (dollars)
- flood probability (percent)[12]

[12] Date of sale was also explored. Prices varied in a range of approximately 10% from year to year when looking at the whole data set. When looking at market segments, properties in the same price range, there was little variation from year to year. Hence the subsequent hedonic models do not include year of sale as an independent variable.

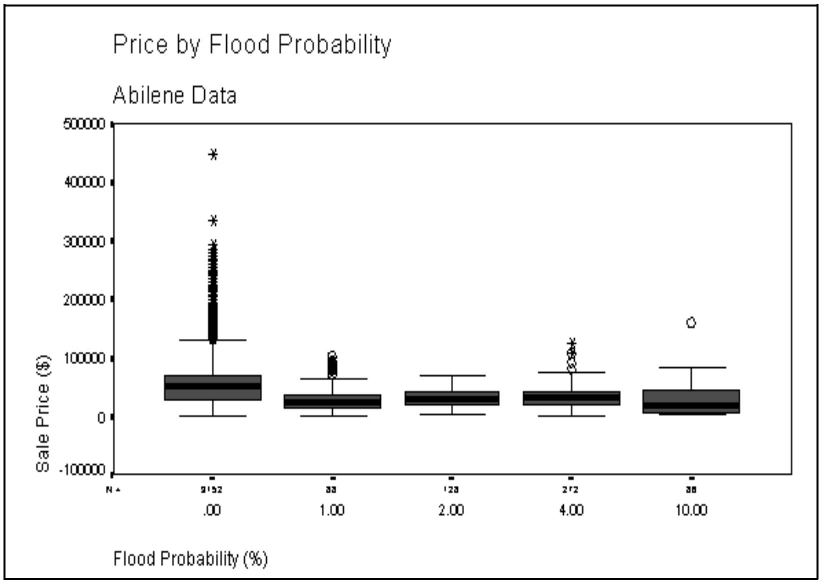

Figure 1 Sale Price by Floodplain Zones.

Figure 1 shows the distribution of observed sales over the flood frequency zones. Probability of zero denotes a relatively flood free location, that is, outside the 100 year floodplain.[13] Percent probabilities of one, two, four, and ten correspond to location within the 100, 50, 25, and 10 year floodplain zones, respectively.

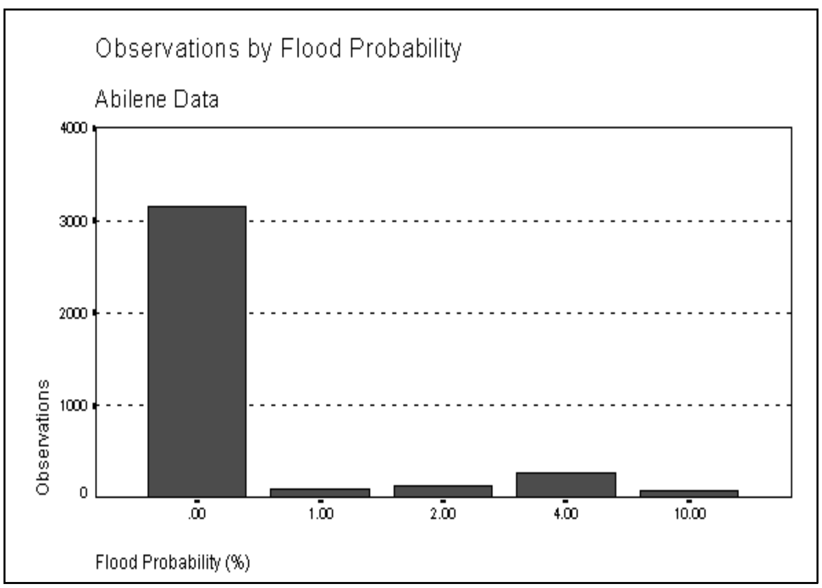

Figure 2 Number of Observations by Floodplain Zones.

[13] Some properties outside the 100-year floodplain may be subject to less frequent flooding and, on average, negligible damages. The 100-year demarcation was used for practical purposes due to data constraints.

The next explorations made were box plots[14] of price, area, and construction date by flood probability (Figures 2 through 4, respectively). It should be noted that the trend of the median does not move monotonically across the floodplain for any of the three variables. This is a reminder that a decision on a house's sale price is based on complex interactions of many factors, of which flood risk is but one.

Figure 2 shows that the median house price is lower in the 100 year floodplain zone than in either the 50 or 25 year floodplain zones. The median house price in the 10 year floodplain is still lower, but the size of the box indicates greater variability in prices in this zone. Figure 3 shows little relationship between area and floodplain zone.

Figure 4 uses age (year built) as the scale variable. It is difficult to discern a trend across the floodplain zones. However, there are some interesting insights. Older development was more likely to be in the floodplain. The fact that newer houses tend to be outside the floodplain could be attributed to increased recognition of the risks involved. However, it could also be due to historical development patterns in which travel corridors and the development of infrastructure, such as water supply, followed streams and houses were built near roads and services. Finally, while most new development is located outside the floodplain, houses were still being built in the floodplain into the current decade. Houses near the streams, those in the 10 year floodplain zone, were still being built into the late 1980s. This is an indication that floodplain

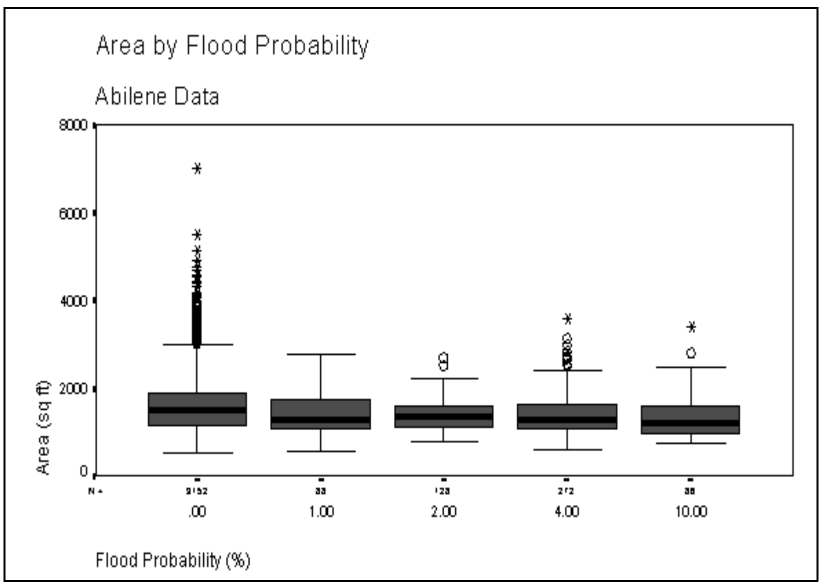

Figure 3 Area by Floodplain Zones.

management and regulation have not been completely effective in controlling floodplain development.

[14]Box plots present summaries of data grouped by some characteristic, in this case flood probability. The box extends from the 25th to the 75th percentiles, with the horizontal line indicating the median. The "whiskers" cover the range of observations within 1.5 box-lengths above and below the box. Outliers (between 1.5 and 3 box-lengths and shown by "o") and extremes (more than 3 box-lengths and marked by "*") are also indicated.

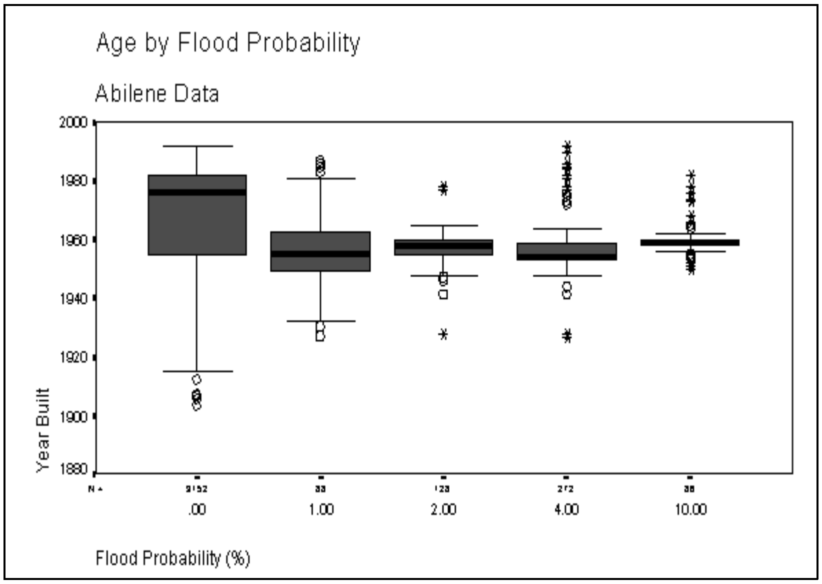

Figure 4 House Age by Floodplain Zones.

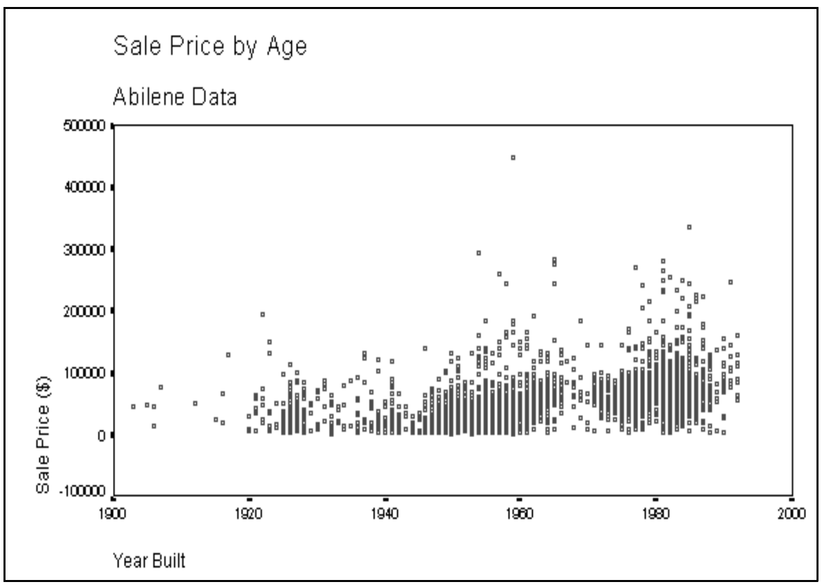

Figure 5 Sale Price by House Age.

Figure 5 shows sale price as a function of construction date. Assuming the age of houses that sold during the study interval were representative of the overall stock of residences, this figure shows the distribution of construction dates in the region. The graph indicates the economic history of the area over the century. The earliest concentration of building occurred in the "roaring twenties," followed by less activity during the Great Depression and the war years. The post-war boom is evident. High interest rates and the oil crises depressed home building during the 1970s. The graph then shows a recovery, noticeably strengthened following the recession of 1981-1982. Figure 5 is a reminder that history matters; the long life of houses means their locations are the result of decisions made at different times and under different circumstances.

Finally, the behavior of the flood insurance premium was investigated, as shown in Figure 6. For those properties with insurance, almost all premiums are in the range of 200 to 500 dollars (There are 519 properties with flood insurance, and the mean premium is $259 with a standard deviation of $120.). Most policies cover houses built prior to 1984, the year of the rate map study. It is presumed that few of the policies reflect actuarial rates. In addition, twenty-nine percent (166 of 574) of houses in the 100 year floodplain have flood insurance. On the other hand, there are 519 houses of the 3726 in the whole data set that have flood insurance. Thus 353 of the 519 insured houses are outside the 100 year floodplain. What seems to matter is the existence or absence of a policy, not the actual premium. Therefore, the hedonic models were implemented using a dummy variable, *Premdum*, with a value of one if a premium was paid and of zero otherwise. Other explorations of the data yielded neither unexpected trends nor noteworthy insights.

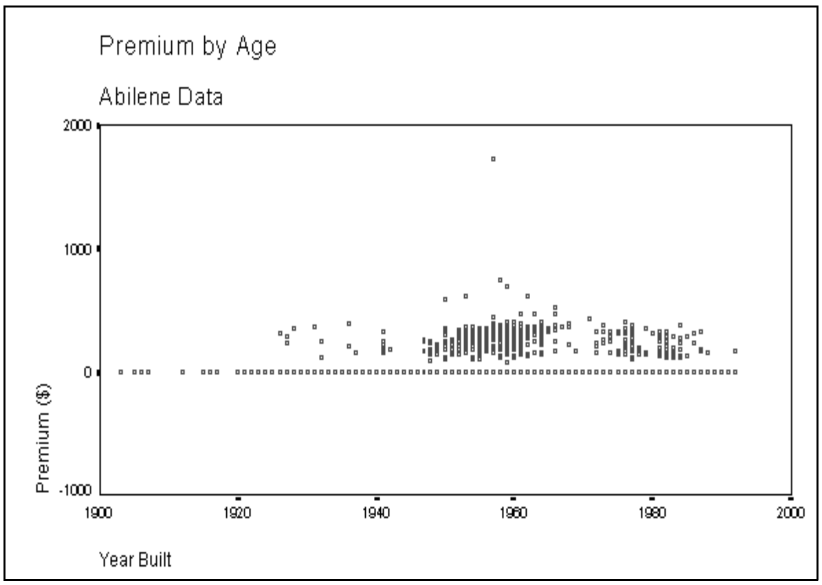

Figure 6 Insurance Premium by Age.

Hedonic Price Models

All models in this case study employed a linear functional form. As noted in Chapter 2, most hedonic studies use either the linear or semi-log functional form. The linear form gave better explanatory power, based on R-squared results, and thus was used for the Abilene portion of this study.

The variables used in the hedonic models and their summary statistics are listed in Table 4. *Price* is the dependent variable in each model. Attributes that reflect the structure of the house are its *Area* in square feet and its *Age* (as of 1993). The percent of high school graduates (*HSGrad*) in the neighborhood (census tract) is used as a proxy for community educational attainment. *Premdum* was discussed above. *Flood1* is a dummy variable with a value of one if the house is in the 100 year floodplain and zero otherwise. *FloodA* is a dummy variable with a value of one for flood free location. *FloodB* through *FloodE* are also dummy variables, taking the value of one, respectively, for location in 100, 50, 25, and 10 year floodplain zones.

Table 4 Summary Statistics from Abilene Data.

Variables	Mean	Standard Deviation	Minimum	Maximum	Number of Cases
Price (dollars)	51,816	36,699	1,500	450,000	3726
Area (sq ft)	1578	598	520	7014	3726
Age (years)	26.9	16.9	1	90	3726
Percent HS Graduate	81.0	12.9	50	94	3726
Premdum	0.13	--	0	1	3726
Flood A (Flood Free)	0.85	--	0	1	3726
Flood B (100 yr)	0.02	--	0	1	3726
Flood C (50 yr)	0.03	--	0	1	3726
Flood D (25 yr)	0.07	--	0	1	3726
Flood E (10 yr)	0.02	--	0	1	3726

Five hedonic price models were made with various combinations of the variables. The first model was identical to the initial model of Griffith and was used to provide confidence that data had been transferred and prepared properly. The results of Griffith's study could not be replicated exactly due to screening of outliers, but adequate agreement between the studies was achieved. However, it soon became apparent that the regression coefficients were not meaningful because the models were derived from the whole data set. Since the data set includes all sales in Abilene from 1988 to 1993, it includes houses for all income groups. Hufschmidt *et al.* [1983] note that the "implicit hedonic price for the entire urban area will be wrong if, as some theorists believe, the housing market stratifies into separate segments."

Data on incomes of purchasers were not collected, so the data set was divided by sale price to account for differences in behavior by income groups. Three segments were initially selected, each with the low end of the range at 80 percent of the high end. The top prices selected for the ranges were $100,000, $50,000, and $10,000. The segment of houses in the $8000 to $10,000 range was found to be a problem on two counts. First, it appears to be too narrow a range to represent a believable limit to behavior.[15] Second, the small size of the sample weakens statistical inference. The F-statistic for this segment was not significant at

[15]Low priced houses may frequently be purchased for the rental market, so the behavioral patterns of low income households may or may not even be important. If investors are involved, the narrow price range is less reasonable.

a 95% confidence interval, indicating that the predictive power of the overall model was low.[16] Therefore, this case was replaced by another which used all houses selling for $10,000 or less. A final case of houses greater than $100,000 was added to investigate the high end of the market.

The descriptive statistics and hedonic model results for each of the sale price segments are shown in Table 5. The descriptive statistics show that the percentage of properties in the 100 year floodplain decreases with increasing house price segment from over 32 % for Run A to less than 2 % for Run D. In other words, the higher income property owners have the wherewithal to choose to live outside of the floodplain. Additionally, flood insurance participation rates vary across the segments (see the *Premdum* mean in the descriptive statistics portion of Table 5). For houses $10,000 or less, only 2.4 % have insurance even though over 32 % of these houses are within the 100 year floodplain. The participation rate rises to 18 % for houses in the $40,000 to $50,000 range. This is approximately equal to the percentage of these houses in the floodplain, although it does not establish a one-to-one correspondence between insurance and floodplain location. For both groups of the more expensive houses ($80,000 to $100,000; over $100,000), the percentage insured is lower, but in each case it exceeds the percentage in the 100 year floodplain. Some owners (24 of 577) of properties outside the 100 year floodplain, but within the 500 year or standard project flood zones, have flood insurance.

Table 5 shows that the R-squared values are low for all the segments because much of the variability within the small price ranges is due to attributes that are not included in the model. Even so, several of the coefficients are significant. The floodplain zone coefficients and the insurance coefficients are discussed in order.

The coefficients for *Flood B* and *Flood C* are not significant at the 95 % confidence level for all the market segments. Griffith [1994] hypothesized that consumers may not be able to assimilate rare events into a value of expected annual damages. This result may be explained by that hypothesis. For properties deeper in the floodplain (10 and 25 year zones), two coefficients are significant at 95 % confidence level, the 10 year floodplain zone for houses priced $10,000 (Run A) and less, and the 25 year floodplain zone for mid-priced houses (Run B) (demarked with double-lined boxes). The magnitude of the coefficient for *Flood E* for Run A, $1735, seems large (although information on expected annual damages was not available) with respect to the average price of the houses for Run A, $6481. It is possible this discount reflects contents damage and intangible flood damage costs.

[16] The F-statistic tests the hypothesis that the variation in the dependent variable is so large that the sample could have arisen from normal distribution (i.e., all the partial regression coefficients are zero).

Table 5 Summary of Results by Market Segment from Abilene Data.

Run	A	B	C	D
Sale Price	$0 - $10,000	$40,000 - $50,000	$80,000 - $100,000	Greater Than $100,000
DESCRIPTIVE STATISTICS				
Number of Cases	297	478	280	294
Price (dollars): Mean (Standard Deviation)	6481 (2244)	45,343 (3091)	88,438 (5944)	140,182 (45,578)
Area (sq ft): Mean (Standard Deviation)	1043 (298)	1486 (336)	2183 (371)	2812 (680)
Age (years): Mean (Standard Deviation)	41.5 (14.2)	26.1 (15.9)	18.4 (14.0)	18.0 (14.3)
Percent HS Graduate: Mean (Standard Deviation)	66.2 (10.9)	82.8 (11.1)	90.7 (5.62)	90.6 (6.58)
Premdum Mean	0.024	0.180	0.082	0.054
Flood A (Flood Free): Mean	0.677	0.828	0.964	0.983
Flood B (100 yr): Mean	0.057	0.006	0.029	0.003
Flood C (50 yr): Mean	0.054	0.048	0.000	0.000
Flood D (25 yr): Mean	0.094	0.105	0.004	0.010
Flood E (10 yr): Mean	0.118	0.013	0.004	0.003
REGRESSION RESULTS				
DF	288	469	272	286
Rsq	0.15	0.08	0.14	0.51
Constant	2636 (2.52)*	40,199 (27.9)*	66,220 (9.60)*	-46,848 (-1.49)
Area	1.43 (3.40)*	2.13 (4.41)*	6.35 (6.36)*	48.1 (17.0)*
Age	11.0 (1.20)	-18.0 (-1.60)	-35.2 (-1.28)	-98.3 (-0.66)
HS Graduate	30.3 (2.46)*	32.1 (2.28)*	101 (1.49)	589 (1.84)
Premdum	2282 (2.78)*	-192 (-0.51)	-2008 (-1.57)	3174 (0.37)
Flood B (100 yr)	-254 (-0.46)	-404 (-0.23)	-576 (-0.28)	-14,531 (-0.44)
Flood C (50 yr)	155 (0.28)	395 (0.59)	Constant = 0†	Constant = 0
Flood D (25 yr)	520 (1.17)	-1595 (-3.39)*	-4874 (-0.81)	995 (0.05)
Flood E (10 yr)	-1735 (-4.31)*	-1842 (-1.48)	5575 (0.96)	-5439 (-0.16)

* t statistic significant at 95% confidence interval
† There are no properties for Runs C and D located in the 50-year flood frequency zone

As for Run B, the model shows that there may be a discount only deep in the floodplain since *Flood D* and *Flood E* are on the same order of magnitude, if one accepts that *Flood E* is only significant to the 80% level. Runs C and D are all statistically insignificant but this may be because there are so few upper income houses in the floodplain and not necessarily because affluent consumers ignore flood risk.

The *Premdum* coefficient was significant and positive only for the houses $10,000 or less. The *Premdum* coefficients decreased monotonically for the segments up to $100,000, although they were less statistically significant. The coefficient for houses in the $80,000 to $100,000 range was -$2008, and its t-statistic of 1.57 indicated significance at 88% confidence. This coefficient is reasonably close to the capitalized value of the stream of premium payments, as discussed above. The *Premdum* coefficient for the highest priced houses had so little significance its magnitude was ignored. It is possible to interpret the trend in *Premdum* coefficients as being the result of subsidies of the flood insurance program. As noted in the discussion of Figure 6, very few of the premiums in Abilene appear to be actuarially set because the properties were largely built before the insurance rate map was set in 1984. The positive sign of the *Premdum* coefficients for the lower priced houses could be the capitalized value of the flood insurance subsidy. The coverage limit of $35,000 for subsidized insurance means that higher priced houses will incur flood losses partially offset by insurance subsidy in the event of a flood. In the mid-range houses, the subsidy and loss may be a financial wash, leading to a coefficient near zero (which is difficult to distinguish from zero and thus has a low t-statistic). For houses in the $80,000 to $100,000 range, the coefficient is actually below the capitalized stream of premiums, perhaps indicating some value for the subsidy.

The non-floodplain variables, area, age, and percent high school graduates in the neighborhood, show some interesting trends. The area coefficients, all significant at 95 percent, rise from $1.43 per square foot to $48.1 per square foot. The age coefficients were not significant at that level, but they did decrease monotonically. The percent high school graduates coefficients increased with house prices, although only in the $10,000 and less and the $40,000 to $50,000 ranges were they significant. Having this level of significance only for low and mid-priced houses may be a result of using percent high school graduates as the attribute for neighborhood quality. By the time house prices top $80,000, there will probably be few high school drop-outs who can afford them. It is not that neighborhood quality is not important, just that percent of high school graduates is not a good proxy. Its import is presumably greater in areas where individuals with lower educational credentials reside.

3.3 South Frankfort, Kentucky

South Frankfort is the site of a Corps market value restoration analysis that was conducted as part of the South Frankfort, Kentucky Re-Evaluation Study [1987]. The study was undertaken to assess the magnitude of the difference in market value of residential properties located in the flood plain as compared to comparable non-flood plain properties within the South Frankfort area. To assess the discounted value of homes located inside the flood plain, the Corps, Louisville District, identified, with the assistance of local real estate agents and community planners, thirteen “comparable” pairs of homes in the area. All of these properties were sold between 1989 and 1991. These properties were paired based on structural similarities, but differed on whether they were flooded in 1978 (a 150-year event). Average annual flood damages were determined for each of the flood plain homes and this amount was capitalized and added to the sales price of the homes in the flood plain. The remaining difference between the actual selling price of the comparable pairs was defined as the estimated restoration of market value. The results showed a statistically significant and negative relationship between sales price and the level of flood risk to the property. The weakness of this analysis is that the “comparable” pairs of homes were chosen subjectively by the real estate agents, community planners and Corps personnel. Therefore the measured difference between floodplain and non-floodplain properties reflect their biases and is not statistically reliable.

The data from the South Frankfort Re-Evaluation Study were used in the present study to obtain a more reliable value of flood risk discount by using a hedonic price model. Although the sample set is small (26 observations), not truly random (drawn from "comparable" residential pairs) and without flood insurance information, this case study was nevertheless pursued because expected annual flood damages, (E[*FD*]), was part of the set. With E[*FD*] and data on actual sales price and flood frequency, the flood location discount, ΔP_L, could be compared with the discount due to primary flood damages, ΔP_D.

Description of the Area and Data Sources

South Frankfort, Kentucky, is located on the Kentucky River. Flooding in the South Frankfort area is frequent and severe. Recent floods include a 150-year flood (1978) and a 40-year flood (1987). Among the 13 flooded properties in the data set, there is significant variation in flood threat.[17] Nine are located outside the 100-year flood zone. Two properties are within the 50- to 100-year flood zone. One is within the 25- to 50-year flood zone. One property has a very high risk of flood frequency, estimated at 13 years at first floor elevation.

The following data were compiled on each of the 26 homes: selling price, total number of rooms, number of bedrooms and baths, house and lot size, and whether or not the residence has a basement (Table 6). Additional data were available (including age of the house, the number of stories, type of construction, porch, fireplace and air-conditioning), but they could not be incorporated into the model because the data were not available for all 26 homes. For the 13 flooded properties, the Louisville District supplemented the above data with data on flood frequency rates and estimated average annual flood damages.

No information on insurance premiums was available. Demographic information on the home buyer and/or general residential area also was not available. Demographic data, such as age, family-size and type, annual income and/or educational attainment level, is often useful to elicit information about the tastes and preferences of the consumer (i.e., the home buyer).

Additional descriptive information is available from the original analysis that suggests that the data were derived from a random sample of all sales during the period. The study sample is relatively homogeneous only in that all the properties are located within a relatively small and contained area, there are common schools and shopping districts, it is racially homogeneous, and almost all the houses were built prior to World War II. Some aspects that make the sample non-homogeneous are that there is significant variation in flood hazard among homes located in the floodplain, and there are some higher priced homes.

[17] The original Corps analysis data set consisted of only 11 comparable pairs since two pairs were removed from the analysis. No explanation was given as to why these pairs were eliminated from the sample set. It is likely that price considerations contributed to this decision since differences in selling price between the two eliminated pairs-- one was very small, $500, and the other large, $110,000-- raised questions about whether "comparable" pairs had been appropriately identified.

Table 6 Data for South Frankfort, KY.

Observation	Address	Price $	Area Ft^2	Flood Freq Years	E[FD] $	Basement Y=1,N=0	Bath	Rooms
1	301 Logan	50000	2186	108	1610	0	2	7
2	107 E. 3rd	43500	2850	100	350	1	2.5	7
3	10 Adele	30000	856	48	640	1	1	5
4	316 Ewing	36500	1635	108	120	0	1	6
5	201 Logan	50000	2360	150	280	1	2	9
6	4 Lyons	32500	1094	92	20	1	1	6
7	320 W. 4th	30000	1351	140	110	0	1	5
8	423 W. 4th	47500	2036	350	30	0	1	6
9	308 Steele	52500	1470	200	300	1	1	6
10	224 W. 4th	25000	1800	13	1490	1	2	6
11	214 Conway	84000	3476	75	1080	1	3	8
12	325 W. 4th	74500	1940	600	230	1	1.5	7
13	229 Shelby	105000	3084	350	120	1	2.5	7
1a	504 Murray	69900	2200			1	1.5	7
2a	324 Ewing	71000	2086			0	2	8
3a	308 Coleman	39000	849			1	1	4
4a	608 Shelby	56000	1400			1	1.5	6
5a	4 Tanner	74000	2202			1	2	9
6a	6 Rockland	54000	1268			1	1	5
7a	202 E. Todd	54500	1231			0	1	5
8a	219 E. Todd	73000	1843			0	3	8
9a	221 E. Todd	53000	1248			1	1	5
10a	123 E. Campbell	73500	1800			0	1	5
11a	10 Rockland	265000	3542			1	3	8
12a	8 Rockland	90000	1554			1	1.5	6
13a	120 W. Todd	141500	3096			0	2.5	10
Means		68300	1941	179	379	0.65	1.67	6.58

* The observations are labeled 1 through 13 for the floodplain properties and 1a through 13a for the "comparable" non-floodplain pairs.

Exploration of the Data and Hedonic Model

Scatter chart diagrams were used to assess which of the available attributes were significant determinants of selling price. The scatter charts revealed a few potential outliers with respect to price: there are two relatively higher priced homes as well as one very low priced home, which happened to be the property located deepest in the floodplain (see Table 6). The hedonic price function was estimated with and without these observations. Removal of these observations helped remedy problems associated with heteroskedasticity among the explanatory variables.

Five different regression equations were estimated. Runs 1 and 2 exclude the three observations where sales price was less than $30,000 or more than $125,000. Runs 3 and 4 exclude only the highest priced home. Runs 1 and 3 include only flood frequency and area, while Runs 2 and 4 include all the independent variables. Run 5 is based only on observations for the flooded properties. This run is included because it was suspected that the non-floodplain properties could possibly have been chosen to exaggerate the price difference between floodplain and non-floodplain properties. Both linear and log-linear hedonic price models were estimated. Only the results of the log-linear models are reported because they have a higher R^2 value than their corresponding linear models.[18]

Although a complete set of data containing five independent variables was available for each of the 26 observations, only two independent variables were included in the model -- flood probability and square feet. The other three independent variables (number of rooms, number of bathrooms and presence of a basement) were identified as partially correlated with square feet. Exclusion of these three variables also increased the degrees of freedom in the regression model.[19]

The preferred regression model was Run 1 because this equation excluded the outliers and because Run 2 showed that basement, rooms and bathrooms are not significant independent variables. Run 1 excludes the property in the 13-year floodplain in order to reduce the possibility that this one observation may dominate the regression model. The likelihood that the property deep in the flood plain is influencing the regression results is evidenced by the instability of the estimated coefficient value for flood frequency with and without this observation (compare Run 1 to Run 3).

The R-squared value obtained for Run 1 is 0.68. The coefficients for each of the variables show the expected sign. Based on this model, both flood probability and total area had a statistically significant effect on the price of the properties sold during the 1989-1991 period, measured at the 1% significance level.

Run 5 is comparable to Run 1 except that the non-floodplain properties were not included in the regression. Although the coefficient for flood frequency in Run 5 is not significant due to the lack of points, it is less than that of Run 1. The probable cause for this difference is that the non-floodplain properties may have been chosen to exaggerate the price differential between floodplain and non-floodplain properties. As a result, the price differential between floodplain and non-floodplain properties calculated below from the equation for Run 1 may be exaggerated.

[18] Whether or not a log-linear (exponential) function accurately expresses the functional form of a hedonic price model requires additional research.

[19] When these three variables were included in the regression function, the model consistently showed that these variables had no statistically significant impact on the selling price of the properties examined. This seems counter-intuitive. One explanation is that the number of rooms and baths in the house are highly correlated with the total area, although running the regression with and without “Square Feet” proved largely inconclusive. Another explanation is that the manner in which the data were collected, namely use of the matched pairs, has introduced bias to the model (i.e., it may not be a random sample of data, given the deliberate matching of housing attributes, although “1/Flood Frequency” does constitute random data.)

Table 7 Summary of Results from South Frankfort Model

Variable	Run 1 (23 obs.) Log-linear	Run 2 (23 obs.) Log-linear	Run 3 (25 obs.) Log-linear	Run 4 (25 obs.) Log-linear	Run 5 (12 obs) Log-linear
DF	20	17	22	19	9
Adjusted R^2	0.6459	0.6339	0.6182	0.5871	0.6369
Constant	10.4658 (81.622)**	10.4685 (43.287)**	10.3450 (67.842)**	10.2104 (36.107)**	10.272 (39.841)**
Basement		0.0968 (1.035)		0.0356 (0.311)	
#Rooms		-0.0189 (-0.348)		0.0298 (0.467)	
#Bathrooms		0.1375 (1.086)		0.1090 (0.692)	
Square Feet	0.000334 (5.084)**	0.000248 (2.154)*	0.000360 (4.770)**	0.000226 (1.569)	0.000355 (3.780)**
1/Flood Freq.	-37.2209 (-4.623)**	-38.1404 (-4.619)**	-14.4420 (-4.246)**	-15.0126 (-4.033)**	-23.202 (-1.627)

Runs 1, 2 & 5: eliminated observations where sales price was greater than $100,000 or less than $30,000. Run 3 & Run 4: eliminated one observation where sales price exceeded $200,000. Where left blank, the respective variable was excluded from estimation. Estimated standard errors are shown in parentheses. Significance level: ** statistically significant at the 0.01 level; * significant at the 0.05 level.

Interpreting the model results

Run 1 shows that price is related to floodplain location, making it possible to calculate ΔP_L. However, it is not straightforward to calculate a ΔP_L from a log-linear model. To isolate the estimated effect of flood probability on selling price, while holding all other factors constant, it is necessary to express this relationship in terms of the elasticity of price with respect to flood frequency. Elasticities measure the percentage change in a dependent variable (price) associated with a one percent change in one of the independent variables (flood frequency). For a log-linear function, the elasticity is derived from the following equation:

$$\varepsilon = \frac{(\partial Y/\partial X)}{(Y/X)} = \beta_1 X \qquad \textbf{(6)}$$

This equation is solved using the estimated coefficient value (β_1) in Run 1, multiplied by the average flood frequency value (0.0042) for the 23 observations of Run 1. The resultant price elasticity with respect to flood frequency is estimated at -0.157. This means that, on average, the sales price of the properties examined will decrease 0.157% for each 1% increase in flood probability. Multiplying the elasticity by the average sales price ($58,430) yields an average floodplain location discount of approximately $9,200. Although the regression model indicates a correlation between price and flood frequency, it is based on only 23 points. Twenty-three points may not be representative of the whole market in South Frankfort.

As discussed in Chapter 2, ΔP_L is comprised of ΔP_D, ΔP_i's and ΔP_j's the discounts due to primary flood damage, negative flood plain attributes and positive flood plain attributes, respectively. The $9,200 is the average discount for location, ΔP_L. Since data were not available to assess the ΔP_i's and ΔP_j's, ΔP_D could not be directly calculated from Equation 5. Nevertheless, the ratio of ΔP_L to the present worth of expected annual flood damages, PW(E[*FD*]), could be compared.

The ratio ΔP_L/PW(E[*FD*]) was calculated for each of the 13 houses flooded in 1978. The PW(E[*FD*]) was taken at four interest rates (2, 4, 6, and 8%), so each of the thirteen houses flooded in 1978 is represented by four markers linked by a vertical line.

Figure 7 shows that outside of the 100-year floodplain (1/*frequency* < 0.01) the ratio varies greatly, while for the three properties within the 100-year floodplain the ratio is constant depending on interest rate.[20] Although flood insurance information was not available, a possible explanation for this behavior is that the three property owners within the 100-year floodplain were knowledgeable about the expected cost of flood damage. These property owners may have been made aware of the cost of flood damage through the requirement that flood insurance be purchased for all properties in the 100-year floodplain.

The properties within the 100- to 150-year floodplain zone were discounted significantly more than PW(E[*FD*]) and over a wide range of values. These properties were all flooded above the first floor elevation in the 1978 flood. For these properties, the owners may have been aware of the flood threat from having heard news of the 1978 flood or from seeing visible residual damage to the properties, but may have been unsure of how to calculate expected annual damages. Since they did not have to purchase flood insurance, they probably had little idea of the expected annual damages. The property owners may also have a difficult time assessing the cost of flood hazard because of the low flood frequencies. In addition, since the hedonic model obtained an R-squared of 0.68, the variability in the ratio is also partly due to the uncertainty in estimating ΔP_L from the hedonic model. Interestingly, the three properties that only had their basements flooded in 1978 did not discount.

In summary, although there is a clear floodplain *location* discount, ΔP_L, for the 13 floodplain properties in the data set, the data set is too small to conclude a discount exists for the South Frankfort real estate market as a whole. Nevertheless, the comparison of ΔP_L with the present worth of the expected annual damages shows that pricing behavior varies significantly across the floodplain. There is a clear change in behavior among those properties within the 100-year floodplain, those within the 100- to 150-year floodplain zone, and the three that had flooded basements in 1978. It is hypothesized that flood insurance, history of

[20] Two outliers are not shown because their ratios are greater than 12 at all interest rates. These large ratios could be interpreted as due to property owners who are particularly risk averse or to expected annual damages that were greatly underestimated.

flooding, flood plain amenities, and awareness of the flood risk cause the price variability.

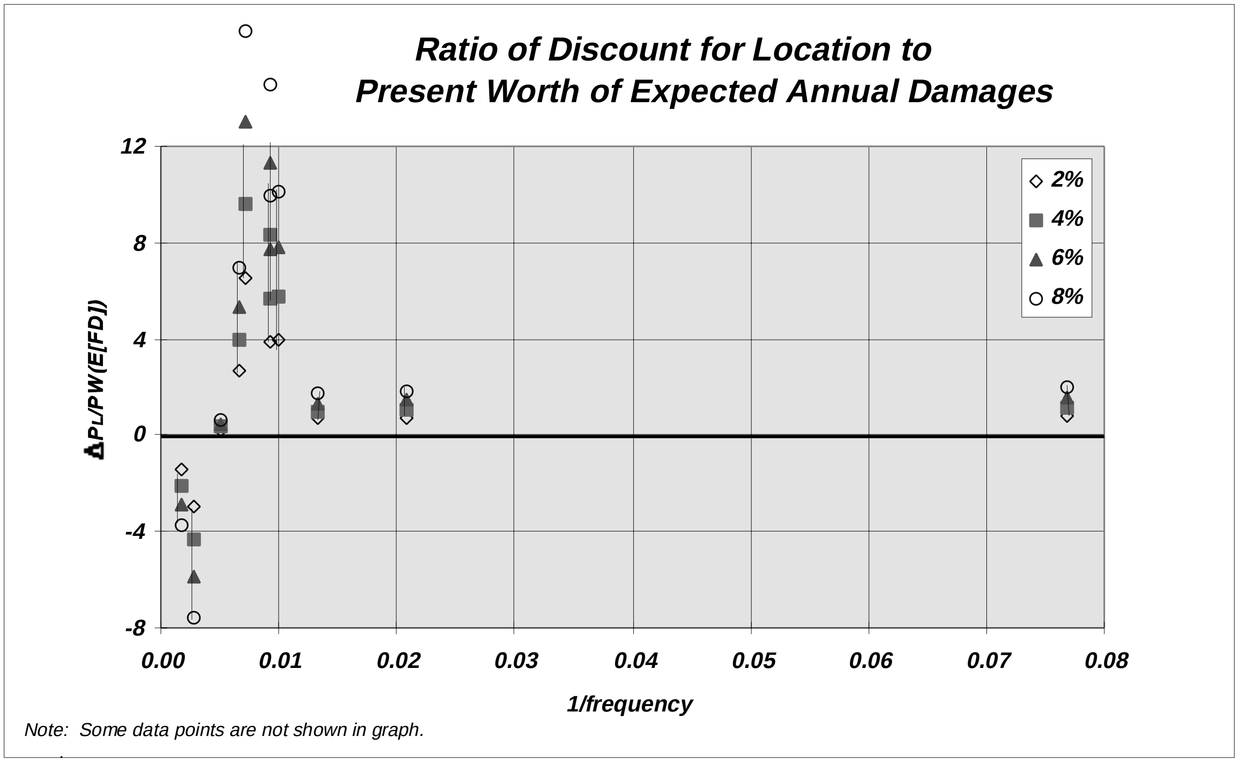

Figure 7 Ratio of ΔP_L to ΔP_D for South Frankfort, KY

Chapter 4 - Findings, Conclusions, and Recommendations

The principal question this study addresses is: *Can empirical evidence be found that flood damages borne by flood plain activities are or are not capitalized into the fair market value of floodplain properties?*

4.1 Findings

Literature Review

None of the 13 reviewed studies found in the literature attempted to directly search for evidence that *flood damages borne by flood plain activities are or are not capitalized into the fair market value of floodplain properties*. Most of the studies attempted to detect a discount for properties *located* in the floodplain (without regard to *where* in the 100-year floodplain). However, a discount for location in the floodplain is different than a discount for flood damages because there are other negative and positive attributes of a floodplain property. Positive attributes, such as access to the water and nice views may result in a premium for floodplain properties. As outlined in Chapter 2, in order to separate a discount for flood damages from a discount for floodplain location, a hedonic price model must include all floodplain attributes. As a result, the principal study question could not be answered through the results of the literature review.

Nevertheless, the literature review offered insights on factors that affect floodplain property prices.

- Eight of the studies used a model that employed the dummy variable of location <u>in</u> or <u>out of</u> the 100-year floodplain. Half of the eight studies show a discount for location (in the floodplain) exists, and half do not. These studies are inconclusive and expected to be so because this model implies that the flood risk is constant across the 100-year floodplain. Flood risk, and therefore any corresponding discount, will vary between properties deep in the floodplain, say within the 25-year floodplain, and those just within the 100-year floodplain.
- Four studies examined the effect of flood insurance premiums. All four found property values discounted by the capitalized value of flood insurance premiums (only where premiums actually are paid). None of these studies distinguished between subsidized and actuarial premiums. Furthermore, only about a fourth of floodplain property owners purchase flood insurance.
- It is not clear whether consumers are risk averse or risk seeking. Two studies hypothesized that consumers may have a difficult time assimilating the effect of rare events into their willingness-to-pay. A contingent valuation study suggests that higher-income consumers may be more risk averse than lower-income consumers.
- The value of positive floodplain attributes was addressed in two studies. Both found the value of positive attributes to be larger than the value of negative attributes (including the discount for flood damages). No academic studies were found that have data sufficient to separate the discount for flood damages from positive floodplain attributes.
- Three sets of researchers studied property prices in the period following a flood. None found a discount in price over the long-term. One study observed a drop in prices followed by a recovery, with the recovery being slower for houses with more frequent flooding. None of these

studies included data on the physical condition of houses, all of which were damaged and then repaired.

Case Studies

The literature review suggested several hypotheses to test in the two case studies. However, since the case studies necessarily were limited to sources of available data, not all pertinent issues could be addressed. In particular, the effects of positive attributes could not be measured, and a detailed analysis of flood insurance effects could not be undertaken. The following paragraphs summarize the case studies.

The Abilene data set was analyzed for floodplain location discount by flood frequency zones (in increments finer than the 100-year zone), and for discount due to flood insurance premiums. Expected damage data were not available. The results suggest that:

- Lower-priced houses (less than $50,000) located deep in the floodplain (within the 25-year floodplain zone) are discounted for location. For other floodplain zones and price ranges, evidence of discount for location was weaker and followed no trend.
- Flood insurance subsidies may lessen the floodplain location discount of lower-valued houses.
- Few higher-priced houses (greater than $80,000) are located in the floodplain. As a result, there is insufficient statistical evidence to determine if higher-priced houses are discounted for flood damage, or affected by flood insurance.

Although the South Frankfort data set indicated a floodplain location discount for all properties that were flooded in 1978 (sales were between 1989 and 1991), it was too small to conclude that there is a discount for the market as a whole. Neverthless, by comparing the discount for location to the present worth of expected primary damages, it was found that pricing behavior varies across the floodplain. More specifically, the results show that:

- for the three properties within the 100-year flood plain, the discount for location is proportional to, and roughly the same as, the present worth of expected primary damages. Although flood insurance information was not available, a plausible explanation for this relationship may be that the owners of these properties have or had subsidized flood insurance and therefore know the expected cost of flood damage.
- for seven properties outside the 100-year floodplain but flooded above the first floor in 1978 (a 150-year flood), discount for location varied greatly and, was generally greater than expected primary damages.
- for the three properties outside the 150-year floodplain and which only had their basements flooded in 1978, there was no discount.

4.2 Conclusions

The findings from the literature review and the case studies are *insufficient* to conclude that flood damages borne by floodplain activities either are or are not capitalized into the fair market value of floodplain properties. The existing studies did not seek and the case studies lacked sufficient data to detect a discount for primary flood damages. In some cases no discount for *location* in the floodplain was detected. In other markets, a discount for floodplain *location* does exist, but varies because of a complex interaction of socio-economic and flood risk factors, such as relative location within the floodplain, flood insurance, and flood history, and positive floodplain attributes. This complexity limits the possibility of identifying specific conditions for when a discount for primary damages either exists or does not exist.

The variability of these factors across floodplain markets around the country makes the assumption that *all* properties are discounted for primary flood damage unreasonable. The assumption that *all* consumers are fully aware of the flood risk and are risk neutral is not supported by the findings. Although the simplifying assumptions are meant to facilitate project evaluation, in the cases where there is no discount, the benefits of permanent evacuation projects are underestimated.

Although recommendations to improve hedonic price models to detect a discount for primary flood damages are possible based on the findings, it may not be fruitful to pursue further such studies. The foremost issue is including positive and negative attributes of floodplain properties in the hedonic price model to separate the discount due to primary flood damages from the discount due to floodplain location. Identifying and measuring all these floodplain attributes is exceedingly difficult. The researcher is hard pressed to identify all the attributes that property buyers consider when purchasing a floodplain property. Even if all the attributes were identified, they remain to be measured. Since these attributes are not traded explicitly on the market, their value must be indirectly assessed with methods such as hedonic price models or the contingent valuation method. Such studies would be expensive and time-consuming because original data surveys would be required. Even if the attributes were measured, several case studies would have to be conducted to establish general conditions for when there is or is not a discount for primary flood damages. Even if several case studies were conducted, their results still may be inconclusive.

4.3 Policy Implications

The findings suggest that greater effort be devoted to analyzing the theoretical and institutional bases for the relevant policies rather than focusing on an empirical basis for justifying the benefits of structural flood protection versus permanent evacuation. The Corps should not expend resources for investigations of the capitalization of flood damages into market values of floodplain properties, either as part of a research project or as part of feasibility studies for flood damage prevention projects.

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Appendix A

Summaries of Reviewed Literature

Babcock, Marion, Bruce Mitchell, 1980, "Impact of Flood hazard on Residential Property Values in Galt (Cambridge), Ontario", *Water Resources Bulletin*, 16(3):532-537.

Babcock and Mitchell hypothesized that flood frequency and experience with a recent flood would lower property values.

Data was obtained for 60 homes in Galt, Ontario from sales records, surveys, and interviews. A program of land acquisition was started after a 1974 flood. The data included these attributes: assessed property value, location in high or low risk flood zones, and flood experience. The authors concluded the market was homogeneous based on similar house ages, house and lot sizes and general appearances. The statistical test was difference in means.

Their findings were that neither location within a low- or high-risk flood zone, nor sale before or after the flood result in statistically significant different sale prices. In their discussion they comment that floodplain location also is a riverine location that could substantially enhance property value. Thus from their results they found that the interplay between flood risk and riverine amenities was dominated by riverine amenities because prices tended to rise. They recommended that further research be done to assess the location advantage of proximity to a river to contrast the disamenity caused by flood hazard.

Comments: The sample size was small.

Bialaszewski, Dennis, and Bobby A. Newsome, 1990, “Adjusting Comparable Sales for Floodplain Location: The Case of Homewood, Alabama”, *The Appraisal Journal*, Jan, pp. 114-119.

The authors tested the hypothesis that property values are lower in floodplain locations.

Their data was for 93 actual sales in Homewood, AL of which 39 were properties within the 100-year floodplain. Other data they gathered were square feet of heated area, finished basement (yes/no), age of a house, number of bedrooms, number of bathrooms, fireplace (yes/no), car storage (yes/no), and months on sale. It appears the market is relatively homogeneous as selling prices ranged from $48000 to $90000 and all the homes are in the same school district. A stepwise-linear regression model was fit to the data.

Location in the floodplain turned out to be a non-significant variable in the regression model. The authors concluded that while floodplain location was not a factor in property values for this community, real estate appraisers cannot generalize these results and should conduct such analyses for each market.

Comments: Stepwise regression models should not have been used, because it can lead to incorrect entry of variables. The salaes data was not well described, although months on sale recorded. They failed to suggest reasons why these results cannot be genearlized.

Donnelly, William A. 1989 “Hedonic Price Analysis of the Effect of a Floodplain on Property Values”, *Water Resources Bulletin*, 25(3):581-586.

Donnelly tested the hypothesis that floodplain location lowers property values. He also compared this possible discount with the capitalized value of insurance premiums.

He obtained sales data for 345 houses in LaCrosse, WI that sold over a two-year period beginning January 1984. Donnelly created a linear hedonic price model with the following independent variables: property tax, age of a house, square feet of finished floor space, garage size, lot size, air conditioner (0/1), fireplace (0/1), neighborhood location, year sold (1984/1985), and a flood variable. The flood variable was the product of a dummy for location in floodplain times the property’s tax liability. Eleven of the houses were dropped from the data set, because they were either brand-new or their tax liabilities were less than $500.

The regression model obtained an R-squared value of 0.838, and it was adjusted to avoid problems of multi-collinearity and heteroscedasticity. The flood variable had a coefficient significant to the 5% level. He found the discount in floodplain properties on average was greater than the capitalized value of insurance premiums. He then hypothesized that a property owners’ perceived risk is different from actuarial risk that may be due to lack of information or a “hassle premium” for having to deal with floods. This discrepancy may also be because pre-FIRM houses did not have content’s insurance available. He ends his discussion warning that these results are for one city and the analysis should be replicated for other locales.

Comments: There was no discussion of functional form of model, it was assumed to be linear. The variable of floodplain location (0/1) times property tax introduces errors that a semi-log model would alleviate. By forming such a variable, Donnelly is assuming expected flood damages are some proportion of the value of the house. A semi-log model would have this assumption built-in. This variable introduces errors, because property tax may not be a fixed portion of actual sale price. Comparison to flood insurance is not complete, since participation data not available.

Griffith, Rebecca Sue, 1994, “The Impact of Mandatory Purchase Requirements for Flood Insurance on Real Estate Markets”, Doctoral Dissertation, University of Texas at Arlington, August.

Griffith examined two hypotheses: 1) “[D]oes enforcement of the mandatory purchase provisions contained in the Flood Disaster Protection Act of 1973 with regard to insurance coverage for homes in Special Flood Hazard Areas affect the selling price of these homes?”, and 2) “[D]oes enforcement of these provisions by lending institutions significantly affect the residential real estate market?”

She obtained data for 4686 actual sales in Abilene, TX from 1989 to 1992. Besides sale price, the data set included the variables: sale date, size, age of a house, percent of high school graduates in a neighborhood, flood frequency zones (10, 25, 50, 100, 200, and 500-year frequencies), insurance premium value, and whether the lending bank enforced the flood insurance purchase requirement (0/1). Of the 4686 properties, 550 had flood insurance policies in effect in 1993. Only 3724 sales were retained in the data set because the remainder had incomplete data. Sale price ranged from \$1500 to \$450,000 with a mean of \$51,000, which suggests the market was not homogeneous. She fit both linear and log-linear hedonic price models to this data set. For the insurance premium variable in the models, she used an index developed by Speyrer and Ragas (1991):

$$\frac{unit\,insurance\,premium \;/\; unit\,sales\,price}{average\,premium \;/\; average\,sales\,price} * 100$$

This index reflects “increasing premium cost related to higher replacement costs for more valuable property” (including contents).

The results show the log-linear models had a higher R-squared than the linear models. She ran three log-linear models in which the flood-related variables differed: 1) only a dummy of whether the house was in the 100-year floodplain, 2) flood frequency only, and 3) insurance premium index and whether flood an insurance purchase requirement was enforced. All these variables had significant coefficients. The enforcement of the insurance purchase requirement had the highest coefficient that says that it is the most influential of the flood variables she considered. Thus, she confirmed her hypotheses.

Comments: Outliers were not properly removed. Our results are very different after removal of outliers. Presence of outlier in her data set made the log-linear model have a high R-squared than the linear model. While she had a large data set, the market was not homogeneous as reflected in the wide range of sale prices.

Holway, J.M., and R.J. Burby, 1990, "The Effects of Floodplain Development Controls on Residential Land Values", *Land Economics*, 66(3):259-271.

Holway and Burby sought "to determine the extent to which floodplain management programs are indeed reducing the value of vacant land in the floodplain. [They] examined three aspects of floodplain management programs: zoning regulations, building elevation standards, and program organizational factors." Their study differs from all the others considered in this report in that they looked at price changes in undeveloped land values rather than developed land. In other words, they looked at developers' profit function rather than consumers' willingness to pay. Since they were looking at profit function, actuarial insurance rates should not affect land values.

They obtained data for nine communities across the country for a total of 317 land sales. The data included only parcels of land zoned for residential development. They formed a linear-log hedonic price model with assessed market value (1985) as the dependent variable. The independent variables were structural protection (1 if there is a levee, dam or flood wall protecting the parcel, and 0 otherwise), flooding history (0 - none 1975-1985 to 3 - 2 floods within five years), percent of parcel in floodplain, zoning index (1 - less intensive to 8 - more intensive), floodplain elevation requirement (0 - no development allowed, 1 - 0 feet, to 3 - 2 feet), floodplain development allowed (0/1), program organization (0 - no lead department or individual to 2 - lead department and oversight individual), parcel size, median city housing value, accessibility variables (e.g., road frontage, shipping distance, work commute time) and neighborhood characteristics (type of adjacent development, ratio of high school education in the adjacent tract). They comment that most authors argue for actual market sales, but recent sales can add selectivity bias. In addition, they note that it has been argued that "the quality of tax appraisals has improved in recent years." They also argue that linear hedonic models may be inappropriate because "the inability of consumers or producers to arbitrage the different characteristics of land and housing." They argue "[t]he linear-log form is appropriate to handle most parcel attributes (those with decreasing, positive slopes of marginal implicity price curves)."

Three hierarchical regression models were used: 1) control variables only, 2) added flood hazard variables, and 3) added floodplain management policy variables. Each model had a higher R-squared over the previous one. The significant flood variables in the third model were flood hazard and flood control characteristics, (+$689 per thousand ft^2 higher than for unprotected land), flood history (floods within last four years, -$288 per thousand ft^2), flood history before last four years (-$182 per thousand ft^2), zoning density ($268 per thousand ft^2), zoning elevation and development prohibitions also lower land value.

The results confirm their hypotheses that zoning flood plains for lower density development, implementing building regulations more stringent than the minimum required by the NFIP, and providing clear local leadership of programs each contribute to lowering floodplain land values. They conclude that NFIP is affecting land use in localities across the U.S., but that its effect can be amplified or subverted by local land-use policy decisions. Compliance with floodplain requirements is estimated to raise residential construction costs between five and 16 percent (Burby *et al.* 1988). They assumed that flood insurance should not be a factor in land value. The reason is that under actuarially correct insurance rates, required for all development, the value of the insurance premiums and the expected value of the insurance payment for flood damage should be equal and cancel each other out.

McDonald, Don N., James C. Murdoch, and Harry L. White, 1987, “Uncertain Hazards, Insurance, and Consumer Choice: Evidence from Housing Markets”, *Land Economics*, 63(4):361-370.

McDonald, Murdoch and White hypothesized that insurance premium differentials provide an exogenous measure to compare with property value differentials derived from the hedonic method. They define an option price as equal to maximum willingness to pay for an improvement in the change of the desirable state (no flooding), holding expected utility constant. So they hypothesized that flood frequency should result in a price differential. Furthermore, they hypothesized that the option price may reflect risk averse attitudes by consumers. Therefore they wanted to see if the hedonic price differential was greater than the insurance rate premium.

They did a case study with market data from Monroe, LA (sales from January 1, 1985 to March 31, 1985). Data included the following: heated square feet of living area, other square feet of living/storage area, number of bathrooms, air conditioning, fireplace, endowment area (quality of the neighborhood), and flood hazard zone (0/1). The flood frequency data only distinguished flood zones to the 100-year level, and not to higher frequencies. They formed the hedonic price model in the Box-Cox functional form. The results show location within a flood zone to be a significant factor (at 5% confidence level). They also took a sub-sample of the oldest and most established neighborhoods (with common shopping, school and tax districts). Location within a flood zone was still a significant factor (at 10% confidence level).

They found for both the full-sample and sub-sample that the hedonic price for being within or out of the floodplain was greater than the present worth of insurance premiums (subsidized pre-FIRM rates taken over perpetuity at 3%). Thus they concluded that “[t]he difference could be a premium resulting from the perception that insurance does not fully compensate for the loss.”

Comments: They provide no information about insurance participation rates nor on floodplain zoning regulations. Prices are based on contingent valuation rather than real sales. Their results concur with Donnelly’s conclusions.

Muckleston, Keith W., 1983, "The Impact of Floodplain Regulations on Residential Land Values in Oregon", *Water Resources Bulletin*, 19(1):1-7.

Muckleston hypothesized that mean assessed values of residential lots within regulated flood plains would appreciate at much lower rates than mean assessed values of adjacent similar lots not so regulated.

Muckleston sought homogeneous study areas, by choosing areas that were zoned for single family residential use, that displayed relative homogeneity in both physical and socioeconomic conditions, and that contained no abrupt topographic changes between regulated and unregulated parcels. In the end, he chose 45 sites in North Albany, OR and 121 sites in Oak Grove, OR.

He tested difference in means of the growth rate in land values for the North Albany site. All study hypotheses were rejected: i) the value of all regulated parcels grew faster than unregulated parcels, ii) the value of regulated parcels built during 1970-76 grew faster than unregulated parcels, and iii) no statistical difference for undeveloped regulated parcels versus unregulated parcels built during 1970-1976.

He divided the Oak Grove data by time periods (1962-81, 1962-69, 1972-81 and 1975-81) and by location within the regulated floodplain (non-waterfront, lake front, and river front). The results were less conclusive, but generally the difference in means between unregulated and regulated parcels was small. Regulated river front parcels did show a statistically significant increase in value over unregulated parcels for the later two periods. He suggested the river front parcels benefited from improved water quality on the Willamette River.

Muckleston noted that his results and conclusions should be regarded as tentative. He hypothesized that the positive attributes of flood insurance availability may outweigh the negative aspects of land-use regulations. Furthermore, floodplain regulations during study were under the emergency phase of NFIP and therefore less stringent than would be under the regular phase.

Comments: The sample size was small. Data was based on assessments rather than actual sales.

Shilling, James D., C.F. Sirmans, John D. Benjamin, 1989, “Flood Insurance, Wealth Redistribution, and Urban Property Values”, *Journal of Urban Economics*, 26:43-53.

Shilling, Sirmans, and Benjamin examined the impact of subsidized and non-subsidized insurance upon property values. They recognized that the flood insurance subsidy is unusual in that it is available for existing structures, but not new construction.

The case study data was taken from 114 single-family house sales in Baton Rouge, LA from December 1982 to February 1984. The hedonic price models included the following variables: age of a house, square feet of living area, square feet of other improved areas (e.g., porch, garage), lot size, type of financing, time trend variable, number of days on market, flood insurance premium, and a dummy variable for whether the property was in the floodplain or not. The neighborhoods from which the data was taken were also checked to confirm the homogeneity of the market. Both semi-log and linear hedonic price models were used. Only results for the semi-log model were reported as the R-squared value was higher.

Two versions of the semi-log hedonic price model were formed: 1) value of the flood insurance premium as an independent variable and 2) dummy variable of location within the floodplain. The coefficients for both variables were found to have the correct sign and to be significant at the 10% level. Given size of the discount due to a flood insurance and average flood insurance premium, they figured out that flood insurance premium implies a real discount rate, in perpetuity, of about 4%.

Comments: Descriptive statistics were not reported, therefore it is not possible to tell how many of the 114 sales included houses with flood insurance and whether the house prices were for a comparable income group. Furthermore, since the mean house price was not reported, one does not know the proportion of house insurance that is subsidized. There was no discussion whether the lending institution enforced flood insurance purchase when making the loan.

Skantz, Terrance R., Thomas H. Strickland, 1987, "House Prices and a Flood Event: An Empirical Investigation of Market Efficiency", *The J. of Real Estate Res.*, 2(2):75-83.

Skantz and Strickland hypothesized that i) there should be no discounting in the floodplain because insurance is so highly subsidized, ii) for the given neighborhood, there should be no discounting after a flood because the flood risk was a well-known fact, and iii) there should be price decreases when there are significant increases in insurance premiums.

They obtained four years of sales data (183 sales) for two adjacent subdivisions in Houston, one flood prone and one not. Property data included: square feet of living area, square feet of lot size, a mortgage guarantee by a governmental agency, month of sale, age of home, whether home was in flooded subdivision or not, sale before or after flood, and sale before or after an insurance rate increase. They formed four semi-log hedonic price models: i) sub-sample with only pre-flood sales, ii) full-sample without the insurance rate increase variable, iii) full-sample without the sale before or after flood variable, and iv) full-sample with all the variables.

The results show the sale before or after insurance rate increase variable to be the only significant variable among the flood risk-related variables. These results confirmed all three of their hypotheses.

Comments: They provide no information on descriptive statistics and on insurance participation rates. Without knowing the mean value of house price, it is not possible to assess how much of the flood insurance is subsidized.

Speyrer, Janet F., Wade R. Ragas, 1991, “Housing Prices and Flood Risk: An Examination Using Spline Regression”, *Journal of Real Estate Finance and Economics*, 4:395-407.

Speyrer and Ragas addressed three hypotheses: “First, within areas with extensive flood insurance coverage and recurring actual flood risk, are property values significantly lower? Second, do differences in insurance cost explain property value reduction in flood-prone areas? Finally, does recurring urban rain-runoff flooding change the magnitude of the adverse effect on property values?”

The data was appraisal reports on single-family houses in two parishes of New Orleans (Jefferson and Orleans). Jefferson Parish is suburban and Orleans is urban. Significant floods occurred in 1978, 1980 and 1983. The data included: price, living area, central air conditioning and heat, number of fireplaces, lot frontage, off-street parking, condition, half-baths, piers, flood zone, and insurance rate index (ratio of unit premium/unit price divided by ratio of average premium/average unit price).

Initially the dependent variable was transformed to Box-Cox form.[21] Given the results of the Box-Cox transformation, they argued that a semi-log form was acceptable and preferable because coefficients for a semi-log model are easier to interpret. In the semi-log model, they included location in the floodplain as an independent variable. In addition, they carried out spline regression with the additional independent variables of location coordinates. Spline regression provides insight for locational variation, in this case floodplain location. The spline regression did not include location in the floodplain as an independent variable, but did include the insurance rate index.

The semi-log model showed location in the floodplain was a significant variable. The spline regression showed price discounts in neighborhoods with frequent flooding. They conclude that “[m]uch of this observed property value reduction is explained by the higher cost of flood insurance which is mandatory in flood-prone areas.” Moreover, they found part of the property value reduction is due to factors other than flood insurance, such as the inconvenience of floods. They also found serious unexpected flooding could lower property values, but repeated flooding does not change insurance cost capitalization.

Comment: The insurance rate index is not necessary for a semi-log model.

[21] Cassel and Mendelsohn (1985) suggest that when many of the independent variables are non-continuous, Box-Cox transformation of the independent variables can be misleading.

Thunberg, Eric, Leonard Shabman, 1991, "Determinants of Landowner's Willingness to Pay for Flood Hazard Reduction", *Water Resources Bulletin*, 27(4):657-665.

Thunberg and Shabman hypothesized floodplain residents are willing to pay for flood control for non-property considerations such as to reduce psychological stress and community disruption. They define an option price, similar to McDonald *et al.* (1987), based on a change in probability of being flooded.

They conducted surveys of floodplain residents in Roanoke, VA (74 total responses). The following data was compiled: willingness to pay for a flood control project, expected change in property damages after a project, expected change in land values after a project, expected change in flood-induced anxiety after a project, expected change in social and economic community disruption, whether an individual owns flood insurance, income of individual and time horizon of individual. The flood insurance variable did not distinguish between subsidized and actuarial insurance. Expected change in anxiety and community disruption are considered the non-property services provided by a flood control project. The hedonic price model in the study was a logarithmic form, because they assumed there is diminishing marginal utility.

The results show all the variables were significant to the 10% level and of the anticipated sign, except the individual's time horizon. Thus, their hypothesis was supported that individuals are willing to pay for reduction in psychological stress and community disruption. The coefficient for flood insurance showed that willingness to pay for flood control was approximately 80% less for individuals who owned flood insurance. In other words, flood insurance was a good substitute for flood control. One concern was 22 of the 74 responses were zero bids for willingness to pay for a flood project ("protest votes"). These responses were dropped from the regression.

Comments: The sample size was small (52 responses) and there were problems of self-selection. No descriptive statistics were provided, so one cannot tell insurance participation rates.

Tobin, Graham A., Burrell E. Montz, 1994, “The Flood Hazard and Dynamics of the Urban Residential Land Market”, *Water Resources Bulletin*, 30(4):673-685.

Tobin and Montz hypothesized that land values are depressed immediately following a flood, but recover subsequently. However, they also hypothesized that the magnitude of the depressed value and the time for price recovery vary according to flood plain location.

They obtained sales data for three case studies, Linda and Olivehurst, CA; Wilkes-Barre, PA; and Des Plaines, IL. Des Plaines suffered two floods during the study period, while the California and Pennsylvania sites suffered one each. Besides housing characteristic data (size, age, rooms, etc), the following flood risk related variables were obtained: number of floods during study period, depth of flood. They plotted changes in mean sale price over time to look at temporal effects of flood risk. They also calculated difference in mean sale price as a function of flood depth for the California and Pennsylvania sites, and as a function of being flooded once or twice for Des Plaines. Similarly they formed a linear hedonic price model, with the same variables of flood depth and number of floods experienced, respectively.

Their results were inconsistent. The Des Plaines data show a price decrease only for those houses that were flooded twice and this price decrease was still present two years after the flood. The California sites show a price decrease that was more severe for homes flooded to a higher depth. The California sites also show the price decreases persisted over two years after the flood. In contrast, they found the Pennsylvania site had no price response to the flood.

They concluded that flood hazard can change house values, but that the change varies among communities which reflect different markets and flood conditions (frequency and magnitude).

Comments: Insurance is never mentioned in the paper. They point out the importance of variation in housing markets.

Zimmerman, Rae, 1979. "The Effect of Flood Plain Location on Property Values: Three Towns in Northeastern New Jersey", *Water Resources Bulletin*, 15(6):1653-1665.

Zimmerman tested the hypothesis that floodplain location affects property values. Zimmerman notes the lack of consensus on this hypothesis. She points out that riverine amenities and subsidized flood insurance provide benefits that counterbalance flood hazard.

Data was obtained for three towns (Oakland, Pequannock and Pompton Lakes) in northeastern New Jersey, all lying within the Passaic River basin. Property values were based on tax assessments. Sample size was 1045, 2822 and 1387 for the three towns, respectively. She did a difference in means test on properties within and without of the floodplain (100 year flood zone) as well as for other variables that might influence property value (size, number of rooms). She discussed the homogeneity of the market in that utilities and access to roads were all comparable.

She concluded that prior to a fully implemented flood insurance program, property values were not significantly different between areas within and out of the flood plain (after standardizing for parcel size and size of unit). She commented that subsidized insurance (the program had only started in 1974, so she had insufficient data on insurance) may actually induce development in the floodplain, opposite the intended effect of NFIP.

Comments: Use of assessed values and owner-perceptions of land value are less revealing than actual sales data. Her comment on subsidized insurance leading to development in the floodplain is ill-founded because subsidized insurance is only available for existing development.

Appendix B

Case Study on Tug Fork, Kentucky and West Virginia

Tug Fork, Kentucky and West Virginia

Tug Fork is the site of a Corps nonstructural flood damage reduction project (flood proofing and permanent evacuation) [USACE, 1993]. Project design required hydrologic modeling and flood damage assessment of a 45 mile stretch of the river. The flood damage assessment data which included house-by-house details lent themselves to hedonic price modeling. The major drawback of the data was property values were based on assessments rather than actual sales. Furthermore, the assessors did not explicitly consider floodplain location in their assessments [Huntington District, Real Estate Division, Personal communication 1996]. As such, it was expected that the hedonic price model would not reveal true consumer preferences.

Description of the Area and Data Sources

Tug Fork forms the boundary between Kentucky and West Virginia. It joins Tug Fork at Louisa, Kentucky to form the Big Sandy River, a major tributary of the Ohio River. The Tug Fork Valley is a steeply cut, narrow valley in the west side of the Appalachian Mountains. Coal, the foundation for the region's economy, is mined throughout the area. Pike County, KY is on the west side of the river. South Williamson is the largest community in the county. Due to the mountainous geography of the area, there is little flat land other than that formed by the river floodplain. As a result, much of the development, residential and other, is close to the stream and subject to flood damage (36 damaging floods recorded since records have been kept).

The data set included house-by-house data on: area, construction type, and floodplain location. Table B-1 shows the descriptive statistics of the data set. Area was calculated by the product of the structure length, the structure width, and the number of stories. Construction types included frame, metal, masonry, and “other”. The “other” construction type included frame\masonry, masonry\veneer, and frame\metal. Floodplain location was delineated by 500-, 100-, 50-, 20-, 10-, and 5-year floodplain zones. Two major drawbacks of this data set was that the sample size was relatively small (540 structures) and the aforementioned appraisal data. Because the appraisals did not explicitly consider floodplain location, it was expected that the hedonic price models would not show floodplain location to be a significant factor.

Table B-1 Descriptive Statistics from Tug Fork Data (493 observations).

Variable	Mean	Standard Deviation	Minimum	Maximum
Appraisal Value	$38,103.45	$42,230.10	$1	$500,000
Area (Sq Ft.)	1550.09	1358.71	96	11,200
Frame	.53			
Metal	.30			
Masonry	.08			
Other Type	.09			
Flood 1	.82			
Flood B (500 yr)	.15			
Flood C (100 yr)	.18			
Flood D (50 yr)	.24			
Flood E (20 yr)	.13			
Flood F (10 yr)	.08			
Flood G (5 yr)	.04			

Exploration of the Data

The data exploration in the case study of Pike County began with data sorting and several uni-variate regression models. Because of the very different financial basis by which commercial and residential properties are purchased or appraised, commercial structures were removed from the data set. The second step was to determine which characteristics of the structures were significant factors of the appraisal value through scatter diagrams and uni-variate regression models.

Figure B-1 shows a plot of appraisal value as a function of the first floor level above the 1977 flood for all the residential structures types. The construction types are denoted by different markers to help display the effect they have on the real-estate market. Distinct appraisal value segments with metal having the least value then frame then masonry and then other can be detected from the graph. Most important, there appears to be little if any increase in appraisal value moving from deeper in the floodplain to approaching flood free. The initial uni-variate regression model (Model 1 of Table B-2) used appraisal value as a function of area. From this model it was evident that area had a substantial effect on the appraisal value of the structures. Model 2 added dummy variables for construction type of which metal and frame were found to have significant coefficients.

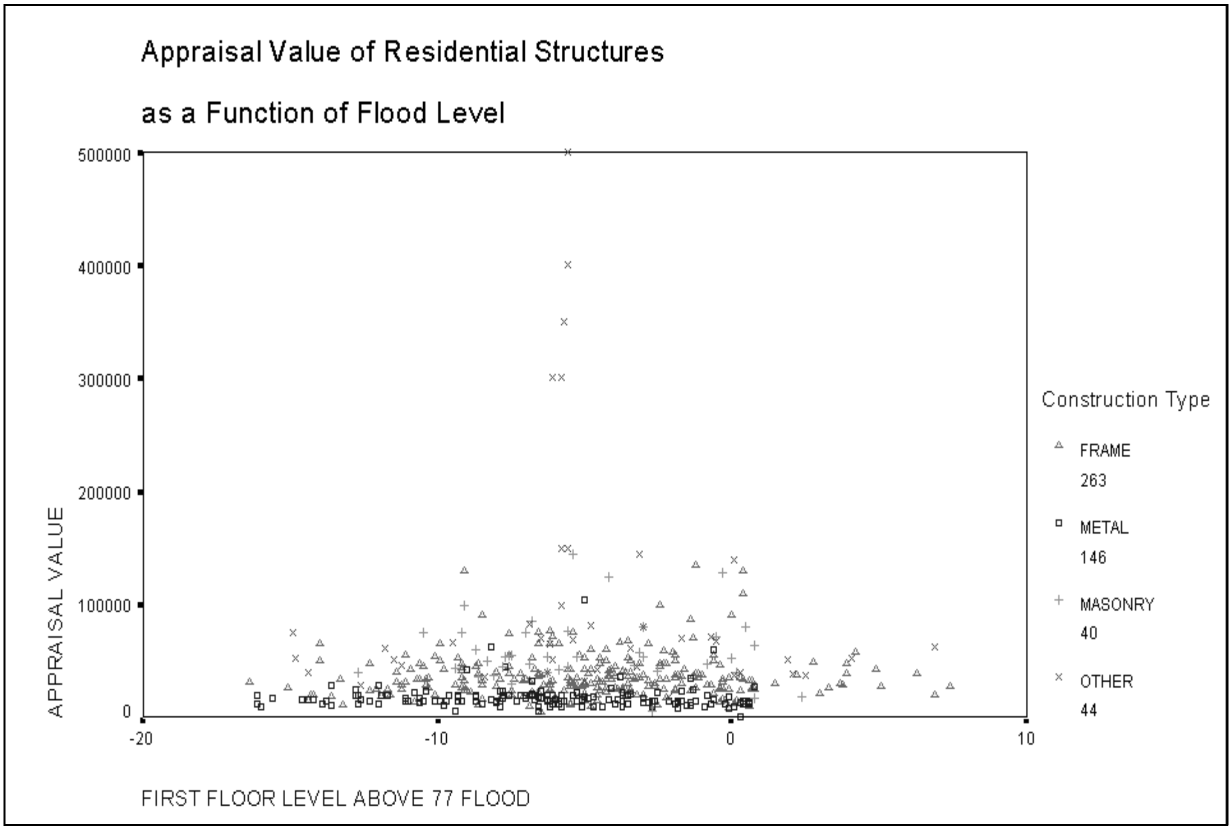

Figure B-1 Appraisal Value Versus Elevation.

Model 3 indicates that *Flood_1* is not statistically significant. Similarly Model 4 shows there is no statistical significance for any of the floodplain zone dummy variables. Model 5, which added the construction type variables, still resulted in statistically insignificant coefficients for the flood location variables. Both frame construction and metal construction remained significant, and the slopes were relatively unchanged. Masonry construction remained statistically insignificant. In summary, floodplain location had no affect upon the assessed value of the properties in any of the models.

As with the Abilene models, the market was then segmented into different price ranges. The results from these models also showed no significance of the floodplain location. Because the segmented market models provided no additional or useful information, the results from these models are not shown.

This case study was pursued and reported despite its drawbacks to demonstrate the need to carefully choose case studies. The fact that the appraisers did not consider explicitly floodplain location when assigning values to the structures is reflected in the results. Two other issues make Pike County less than ideal for hedonic price modeling. First, Pike County presents a unique market condition with many of residences remaining within the same family for many generations, such that sales may not reflect true market values. Second, because of the topography of Tug Fork, the market is not fully competitive in that there are few comparable housing alternatives outside of the floodplain.

Table B-2 Summary of Results from Pike County Kentucky Models.

Model	1	2	3	4	5
DF	491	488	490	485	482
R-squared	0.671	0.682	0.672	0.674	0.684
Constant	-1373 (-0.829)	14,810 (2.98)*	-2647 (-0.942)	-2216 (-0.783)	13,698 (2.54)*
Area	25.5 (31.7)*	23.9 (24.9)*	25.4 (31.6)*	25.1 (30.1)*	23.5 (23.7)*
Flood 1			1604 (0.561)		
Flood B (500yr)				596 (0.154)	799 (0.208)
Flood C (100yr)				5937 (1.60)	5834 (1.58)
Flood D (50yr)				655 (0.192)	1040 (0.308)
Flood E (20yr)				-526 (-0.132)	322 (0.082)
Flood F (10yr)				1136 (0.243)	660 (0.143)
Flood G (5yr)				646 (0.107)	786 (0.130)
Frame		-16,321 (-3.77)*			-15,930 (-3.63)*
Metal		-14,737 (-3.00)*			-15,059 (-3.03)*
Masonry		-7538 (-1.40)			-7003 (-1.28)

Figures in parentheses are t-statistic values. An asterisk indicates significance at the 95% confidence interval.