AN ABSTRACT OF THE THESIS OF

Mark Steven Doverspike for the degree of Master of Science in Agricultural and Resource Economics presented on April 18, 1980

Title: Predicting the Impacts on Residential Property Values from Changes in Water Quality

Abstract approved: Kenneth C. Gibbs

Eutrophication is the accelerated aging process of a lake which generally decreases the water quality in terms of aesthetic and recreational uses. At Liberty Lake, near Spokane, Washington, eutrophication has become a problem. Many individuals and agencies are interested in the benefits that occur when the lake's water quality has improved.

In this research the benefits to private property owners were measured at Liberty Lake. Three methods -- present sales, appraised value and personal interview -- were compared and empirically tested to determine the economic benefits to private property owners as well as the overall community impact. For this study property was defined as land, buildings and other improvements.

Current market sales and appraised values at six different lakes, each with different water quality levels, were used as the dependent variables for the present sales and appraised value methods. The dependent variables were regressed against several factors including physical (housing, neighborhood, accessibility, and environmental characteristics) to estimate the effect water quality had on property values. A quadratic and double logarithmic function were examined. In the results a positive

relationship was found between water quality and the dependent variables. A 100 percent increase in the water quality ranking resulted in a $3,800 increase in the sales price per lot and $884 increase in the appraised value per lot for the quadratic function.

Separate equations were determined for vacant lots. The dependent variables were the same, but only neighborhood, accessibility and environmental characteristics were used to estimate the effect water quality had on property values. In the quadratic form with a 100 percent increase in the water quality ranking, sales price increased $556 per lot and appraised value increased $782 per lot.

In the personal interview method home owners at Liberty Lake were interviewed and asked for how much they would be willing to buy and sell a particular home at different water quality levels. The differences between the two buying and selling prices were the estimated impact of a change in water quality and totaled $4,795 and $5,679, respectively. Both differences were significant at the one percent level. The buying price difference was used when comparing the personal interview method to the other methods, since it was less likely to overestimate the water quality effect.

This research used the best water quality index available, but there is a definite need for future research to develop a uniform water quality index.

Predicting the Impacts on Residential Property Values from Changes in Water Quality

by

Mark Steven Doverspike

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed April 18, 1980

Commencement June 1980

APPROVED:

Associate Professor of Resource Recreation Management
in charge of major

Head, Department of Agricultural and Resource Economics

Dean of the Graduate School

Date Thesis presented April 18, 1980

Thesis typed by Dodi Snippen for Mark Steven Doverspike

ACKNOWLEDGEMENTS

The author is indebted to many persons for advice and reassurance in the preparation of this thesis. In particular, I would like to thank:

Dr. Kenneth C. Gibbs, as a co-major professor, for his many hours spent advising and assisting in constructive criticism in the development of this thesis.

Dr. Herbert H. Stoevener, a co-major professor, for his help and direction in my academic program and this work.

Graduate committee members -- Dr. David R. Thomas and Dr. James K. Whittaker -- for their help and direction in this work.

The faculty of the Department of Agricultural and Resource Economics, many unnamed friends and associates for assistance, ideas and support throughout the study.

The Environmental Protection Agency for the financial help through project R805861010 to pursue this research and degree.

My wife, Susan, for her help and encouragement during my graduate study.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

PREDICTING THE IMPACTS ON RESIDENTIAL PROPERTY VALUES FROM CHANGES IN WATER QUALITY

CHAPTER I

INTRODUCTION

The accelerated aging process of a lake generally decreases the water quality desired for aesthetic and recreational purposes. This acceleration can be caused by factors such as intensive fertilizer leaching from adjacent hillsides and human wastes discharged into the lake. These inputs over fill the lake with nutrients. From the increased nutrients the water quality changes significantly and often rapidly.

This water enrichment process is referred to as eutrophication (Simmons, 1974). Eutrophication can have both beneficial and adverse effects. One benefit is fish have a higher nutritional plane. Better nutrition enhances reproduction. A drawback is increased algae and weed growth. This increased growth may annoy swimmers and boaters using the lake, or lower the aesthetic value, or cause an offensive odor.

Extensive research on the physical and biological aspects of lake eutrophication is being conducted by the Environmental Protection Agency (EPA) staff. They are also researching technical and feasible methods to improve water quality. Before these methods can be implemented they should be evaluated for economic feasibility. This means that the benefits of lake restoration should exceed the costs. Most of the costs are relatively simple to compute. Benefits that occur due to water quality changes are difficult to calculate. When examining these benefits a person needs to start with the basic theory of rent.

Classical economy theory of rent indicates that land productivity varies from location to location. Land rent, a more specialized concept, represents the theoretical earnings of land resources. It can be defined as the "economic return that accrues or should accrue to land for its use in production" (Barlow, 1972). Theoretically this idea pertains to all land income and, as used here, applies to the combined income from lot and site improvements.

This reasoning has aroused interest in determining a relationship between land rent, or some form of land value information of residential property, and environmental quality (e.g., water quality). The relationship is used in measuring the benefits to property owners. Ronald Ridker (1967) used residential property value data as the basis for estimating the benefits from a change in air quality and reasons as follows:

> "If the land market were to work perfectly, the price of the plot of land would equal the sum of the present discounted streams of benefits and costs derivable from it. If some of its costs rise (e.g., if additional maintenance and cleaning costs are required), or if some of its benefits fall (e.g., if one cannot see the mountains from the terrace) the property will be discounted in the market to reflect peoples evaluation of these changes. Since air pollution is specific to locations and the supply of locations is fixed, there is less likelihood that the negative effects of population can be significantly shifted to other markets. We should therefore expect to find the majority of effects reflected in this market, and we can measure them by observing associated changes in property value" (p. 25).

One can extend this argument by saying that water pollution is specific to locations and the number of lakes is fixed. It is less likely that the negative pollution effects can be significantly shifted to other markets. Therefore we can argue as Ridker and say that we can measure the impact water quality has on property values.

This measurement can be very important to decision makers when decisions on broad policy issues are made (i.e., restoring water quality in a lake). This study attempts to estimate the economic impacts water quality changes have on private residential property values surrounding Liberty Lake, Washington. At the same time the study compares different methods to measure that change.

Objectives

The objectives of this thesis are to:

(1) Empirically test three methodologies to calculate the economic benefits of a water quality increase to individual property owners, as well as an overall community benefit, surrounding Liberty Lake, Washington.

(2) Compare the methodologies and identify the strengths and weaknesses of each.

This study is important for at least three reasons. First, the research provides results so decision makers can attempt to allocate the appropriate amounts of public funds to improve water quality. Second, it is anticipated that the methodologies studied will be useful in the evaluation of private property owner's benefits resulting from water quality improvements. Third, future researchers will be able to examine the strengths and weaknesses of the methodologies. This will aid them in choosing an appropriate method to accomplish their objectives.

Study Area

The primary objective is to measure the effect a change in water quality had on the residential property at Liberty Lake, Washington. In order for the market sales and appraised value methods to have a large variation in the water quality, data from several lakes were needed. Each of the lakes is described below.

Liberty Lake is situated approximately 15 miles east of Spokane, Washington. The 781 acre lake has an average depth of 30 feet, receives runoff from a 13.3 square mile watershed, and is predominately a recreational lake. Land adjacent to the lake is primarily residential. Residential development completely surrounds the lake except for a publicly owned boat ramp, park and wildlife refuge. Development extends away from the lake between a quarter and a half mile. Residents have access to public water and sewer systems. At the time of the study four private resorts were operating, two of which had boat ramps. The small town of Otis Orchard is about five miles from the lake.

The other lakes used in the market sales and appraised value methods were Newman, Badger, Silver, Medical, and Clear Lakes; all in close proximity to Spokane. Newman Lake, the largest of the lakes covers 932 acres and is located 23 miles northeast of Spokane. The small town of Otis Orchard is seven miles from the lake. The average depth of the lake is 35 feet. Residential development almost surrounds the lake shore except the west side. The land located on the west side is privately owned and is used for summer cattle range. There is no public water or sewer system at the lake. Public access is limited to a public boat ramp with a small beach and two resorts, one of which has a boat ramp.

The average depth of Badger Lake is 60 feet, making it the deepest of the six lakes. Badger covers 249 acres and is 32 miles southwest of Spokane. Cheney is the closest town and is 11 miles from the lake. A small percentage of the lake shore is developed. There are no public services (water and sewer systems). There are two small marinas and both have some overnight facilities and boat ramps.

Silver Lake is located 14 miles southwest of Spokane and one mile south of the small town of Medical Lake. The lake's average depth is 50 feet and covers 500 acres. The lake has a public access facility, which includes a boat ramp and beach. Three resorts are located on the lake shore, two have boat ramps and all three provide overnight facilities. This lake is primarily a fishing lake, where motors on the lake are discouraged and no water-skiing is allowed. Less than half the lake shore is developed and there is no development away from the shore. No public services are available at the lake.

Not more than one and a half miles west of Silver Lake is Medical Lake. The lake's average depth if 45 feet and covers 207 acres, making it the smallest lake of the six lakes. Medical Lake is 13 miles southwest of Spokane and is bordered on one side by the town of Medical Lake. Public services are available and two parks, one owned by the city, the other by the state, are located on the lake shore. The state park has a boat ramp. Neither park allows overnight use. Half of the lake shore is developed within city limits and the other half is state owned. There is no development on the state's property other than the park. Water-skiing and swimming are allowed at the lake, but fishing will not be permitted until at least 1981.

The final lake, Clear Lake, is located 22 miles southwest of Spokane and four miles southwest of the town of Medical Lake. The lake covers 350 acres and has an average depth of 55 feet. The public has access to it by a state owned facility which includes a boat ramp and small beach. There are also three small resorts, all with boat ramps and overnight facilities. Most of the development is away from the lake shore between an eighth to a quarter of a mile. A community water and sewer system is available.

Organization of Thesis

In Chapter II previous research analyzing the environmental quality-land value relationship is briefly reviewed. Chapter III is devoted to developing theoretical models to determine the relationship between water quality and property values. The statistical models, variables used in the models, and the selection of the samples are discussed in Chapter IV. The empirical results and final equations for the methodologies are discussed in Chapter V, as well as the estimated economic value of an improvement in water quality. Chapter VI contains the summary and conclusions and limitations of this study and recommendations for future research.

CHAPTER II

METHODS TO DETERMINE ECONOMIC VALUE OF WATER QUALITY CHANGES

Measuring Property Value Effects

There are basically four methods to estimate environmental impacts upon real estate values. The first method is the present sales method. Actual sales data from market transactions are used. The second is the appraised value method which uses a professional appraisal to estimate the market price. The other two methods rely on non-market mechanisms for obtaining information. One such non-market mechanism is the personal interview method which procures value estimates from prospective buyers and/or sellers. Another poses the question as a referendum issue of what level the public good should be supplied. This study considers residential property as a complete unit consisting of land, buildings (where applicable), and any other improvements, since residential property is commonly purchased on that basis.

Market Sales Method

The market sales method uses market information on transaction between many buyers and sellers. The assumption for the market sales method is each sales price is determined by the intersection of the demand and supply curves for homogeneous properties. The demand for residential property is influenced by the consumer's income and preferences for property, access, neighborhood characteristics, recreational and aesthetic values. Supply is determined by all costs of production (including land price and building costs). Assuming a normally operating real estate market, property price represents the price of a residential property plus an extra amount representing a recreational and/or aesthetic value, where such values exist.

This recreational and/or aesthetic value can be measured in one of two ways. One is by comparing property values that have aesthetic influences or impacts with those that do not. The second is by comparing property values that all have aesthetic influences or impacts of different degrees. This could be done using several lakes with the same type of activities but different levels in water quality or the same lake with a recorded change in water quality over several years. The data for either can be analyzed using multiple regression.

Appraised Value Method

Real estate appraisals are used instead of actual market transactions in the appraised value method. The appraised property value should include land, improvements, neighborhood charateristics, access and a recreational and/or aesthetic value. The appraisers' estimates may not accurately reflect the true market value because all appraisals are subject to some biases (political or other reasons) (Freeman, 1979). Also appraisals tend to follow or lag the changes in market values. Determining the recreational and/or aesthetic value can be done the same way as in the market sales method.

Personal Interview Method

From the personal interview method aesthetic and/or recreational values are estimated through personally interviewing home owners or by obtaining opinions of prospective buyers. There are two kinds of problems that can arise when deriving demand information from interviews.

The first is the way the questions can be asked and in which the respondents expect the answers to be used. This may induce the respondent to provide distorted or biased information in an effort to influence the outcome in some way. It is possible to design questions in which there are no biased responses, but this leads to a second problem. That problem being no positive incentive to provide accurate responses. If an individual must spend time considering the responses, a positive incentive may be required to elicit the necessary effort to provide accurate information.

There are several ways for eliciting the aesthetic and/or recreational values. Individuals could simply be asked to state their willingness to pay. They could be asked to indicate whether a value proposed by a questioner is too high or low. For this method the proposed values are adjusted by some value until the individual indicates that the value is neither too high nor low. To indicate preferences among several types of public goods, individuals could be asked to allocate a fixed budget or scrip among alternatives in accordance with their preferences.

Referendum Issue

This method determines, through a voting process, if and how much a good (private or public) should be provided. The assumption is that decisions are made directly through the interaction of the individuals concerned (Breton, 1974). Therefore individuals attempt to satisfy their preferences through face to face bargaining, or vote trading, or issue voting, or any other scheme in which citizens are involved directly in deciding on the supply of goods.

When public good supply decisions are made by referendum, voters can only respond by a yes or not vote on a proposed level of the public good. A no vote implies that the quantity demanded equals zero. When a referendum passes, it is assumed that the quantity demanded approximates the median preference of the jurisdiction; and any divergence between actual outcomes and median preferences for a particular jurisdiction can be assumed small and averaged to zero (Freeman, 1979). Given these assumptions, each jurisdiction can be a sample unit. And the data on public good quantity, price or tax share, median income and socio-economic characteristics for each jurisdiction can be pooled and a demand function for that public good can be identified.

Previous Analysis

Previous studies have analyzed the impact recreational and environmental resources have on land values. Some analyses were based on the market sales method while others used the appraised value method. One of the first studies was done by Knetsch (1964), who used the market sales method. He studied the effects several Tennessee Valley Authority (TVA) reservoir projects had on land values. He than projected the results on land values of other proposed TVA reservoir projects. Knetsch compared two real estate situations. One was a reservoir model based on property sales surrounding several TVA reservoirs; the second was a non-reservoir model based on property sales in non-reservoir areas. The difference between the land values from the two models was the land value effect attributable to the proposed project.

The non-reservoir model explained 58 percent of the land value variation while the reservoir model accounted for 76 percent. The standard error of the predicted sales was so large (70 percent and 30 percent of the mean sales in the non-reservoir and reservoir models, respectively) that the magnitude of the change in land value accountable to the reservoir was questionable.

David (1968) extended Knetsch's model in a study of Wisconsin lakeshore property values. Her ten year study of 60 artificial lakes analyzed land values and improvement values. The values were regressed against several independent variables to determine which characteristics were important in predicting property values. The independent variables included access, presence of swamp, topography, pollution, proximity to population centers, and the presence of other lakes. David divided the lakes into three groups by using two subjective measures of pollution. The measures were the opinion of a member of the Department of Conservation and the opinion of a member of the Committee on Water Pollution. She ranked the water quality as poor, moderate, or good. Dummy variables were used to represent each level of water quality. David found that water quality, proximity to population centers, and the presence of other lakes in the area were all positively related to property value. The per acre improvement value resulting from improved water quality for 1962 was $2,260.

David and Lord (1969) examined values of rural lands up to 40 acres in size bordering artificial lakes throughout Wisconsin using the appraised value method. They found that real estate values, in proximity to the recreation lands, were related to improvement value, tract size, pollution, topography, population, and access to economic and social activities. The improvement value and tract size were obtained from assessors records. Pollution was measured the same as in David's study.

Schutjer and Hallberg (1968) found that investments in water-based recreation facilities do significantly influence the value of rural property and the structure of the rural land market. They used the market sales method and the data for this study were property transactions located near a 2,250 acre water-based state park. The park is within 20 miles of two relatively large population centers in Pennsylvania. They used 20 variables to analyze the way in which the housing market was altered by park development. Also examined was the effect the park development had on a per acre value of different property types located in the nearby area. Taking sales transactions before and after the announcement of a reservoir development and using multiple regression analysis, they observed a significant impact on the market structure due to the increased availability of water recreation. To obtain more homogeneity of the data they divided the sales into four classes of properties--more than two acres with buildings, more than two acres without buildings, two acres or less with buildings, and two acres or less without buildings. The effects the announcement had on property values were measured using several interaction terms. The pairwise interactions were between number of acres, road distance in miles to nearest park entrance, road frontage per acre, and a dummy variable representing the difference between property transferred before and after the announcement of the reservoir construction. Significant variables from this study included acres transferred and road distance in miles to the nearest park entrance. The findings of this study supported the general hypothesis that investment in water-based facilities significantly influenced the value of rural property and structure of the rural market. It should be noted that Schutjar and Hallberg studied rural tracts in one geographic area only.

The effect on land values due to the distance to a stream or park was studied by Coughlin and Hammer (1973). This study was done on urban residential property values in a Wisconsin upper-middle class neighborhood. They used market sales method to estimate a location rent per house and lot which declined with distance from a stream or park. Location rent was defined as payments for land based on the location to the stream or park. Total property sales price was used as the dependent variable. From the analysis a value for the residence and a base value of land was found. This resulted in the distance due to location preference explained by the distance from the park. More than 10,000 dwelling units were analyzed. A dummy variable was used to indicate the type of house. From this research it was shown that persons living near a recreational area can more easily derive benefits from that resource than persons living farther away. Beyond a certain distance people derived no measurable benefits from the recreation area. The location rent gradient dropped off rapidly with distance from the park or stream.

Boodt (1978) developed a two-part economic model to estimate recreational and environmental effects upon rural residential non-farm property values in Lane County, Oregon. The first part deals with property values that are in proximity to and influenced by recreational and environmental resources. The second part estimates values that are not in proximity to and not influenced by these resources. In both parts multiple regression was used. His findings revealed that lot size, distance to a central city, and distance to the reservoir were most significant in explaining property values. Boodt also found that the importance of accessibility was not as significant as originally indicated by past studies.

Other studies using multiple regression analysis include Burby III (1971), Darling (1973), and Day and Gilpin (1974). Burby found that the key variables influencing residential location were quality of road access, shoreline accessibility, and availability of public utilities. Darling attempted to show that the value of an urban park is not elusive, and intangible quantities can be measured. The major weakness of Darling's study, sample size, did not permit significant results. Darling believed that both a direct method and property value model were legitimate ways to evaluate "intangible benefits". Day and Gilpin used four variables to describe the assessed residential property values. The variables were distance to reservoir, age of home, floor area, and type of dwelling. The only two significant variables were floor area and distance to reservoir.

Mann and Mann (1968) did a trendline analysis on property values before and after the announcement of a reservoir project. This trendline used sales prices of residential property in an area of Mississippi. They plotted all property sales as the control base ten years before the announcement of the dam project, and followed prices five years past the announcement. They found a substantial increase in property values after the announcement of the project. Mann and Mann assumed a nine percent increase in land value from the control data. In the first year after the project announcement they measured a 116 percent increase. For the first six months of the second year there was an increase of 270 percent.

Conner, et. al. (1973) tested two methods of estimating the value of water frontage on residential property in the Kissimmee River Basin, Florida. The first method used market prices and property characteristics with multiple regression to develop a model explaining the values of unimproved residential lots. Several independent variables including lake frontage (absence or presence), lot size, year of sale, miles to nearest paved road, and number of utilities available were shown to be significant. From the second method the owner's estimates of the property value with and without water frontage were obtained. The first method (lot sales analysis) estimated that lake frontage would contribute 65 percent to the total value of a typical vacant residential lot; while from the second method it was found that lake frontage contributed 48 percent to the developed property's total value.

Freeman (1979) believed that a comparison among several lakes would help determine the property value-water quality relationship. These lakes should be popular for resorts, residential, second home use, and have different water quality levels. He indicated that the data should contain property values, characteristics of the lot and structure, locational characteristics, and some measure of water quality. Property values should be measured by actual market transactions. Freeman judged that the second best property value data source was the professional appraisals of the individual properties for taxation purposes. He also quickly pointed out that appraisals must be used with caution, since some areas may be systematically biased for political or other reasons. Freeman postulated the year the house was built, lot size, structural material, location on street, form of heat, number of bathrooms, with or without basement, and number of rooms should be included as lot and structure characteristics. Location characteristics would include distance from urban centers, public road quality, and surface area of lake. Using the above data and the hedonic price equation, Freeman then argued one could calculate the implicit water quality price. Then with additional income and other socio-economic characteristics of the household, it is possible to identify the water quality demand curve in a second stage estimation.

David (1971) did a study in Wisconsin on how people perceived water quality. She took a representative sample of adults, interviewed them, and analyzed the data three ways: cross tabulations, automatic interaction defector analysis, and multivariate analysis. The study results showed that in general poor water quality is more likely to be mentioned by those who live near it than those who do not. When asked to describe pollution, the respondents mentioned algae and murky, dark water, but did not often mention such things as chemicals or disease germs. Weeds were not considered to be as much a nuisance as algae. Women more than men seemed to feel that pollution was a problem. People who live in small towns considered pollution a bigger problem than people who live in urban areas.

Ditton and Goodale (1973) used an open-ended question to get people's perceptions of Green Bay, Lake Michigan. They interviewed heads of households participating in boating, swimming, and fishing, then used chi-square tests to analyze the data. Their findings indicated that swimmers and boaters differed most in perception of the bay's troublesome characteristics, and fisherman occupied a position between the swimmers and boaters. The physical characteristic felt to be most bothersome was "unpleasant smell" followed by "junk on the bottom" and "too many weeds".

This thesis utilized the present sales, appraised value and personal interview methods since they appear to be conceptually sound approaches. These methods were also chosen because of their diversity and comparisons will improve future research by identifying their strengths and weaknesses. The referendum method was not compared because not enogh information was available to use this method.

CHAPTER III

THEORETICAL MODELS

Economic models were developed to test the hypothesis that as lake water quality improves the surrounding residential property values increase.

This study examined three different models. All of these models attempted to estimate the effect of water quality on property values. The market sales and appraised value methods examined properties with and without buildings and improvements. The personal interview method used only properties with houses because it would have been costly and difficult to locate property owners of vacant lots.

Market Sales Method

The model developed for this study concentrated separately on the decision to purchase housing stocks or vacant lots. A hedonic model based on property characteristics was used. The hedonic technique is a method to approximate the implicit price of characteristics which differentiate closely related products in a product class (Freeman III, 1979). For example, houses constitute a product class differentiated by several characteristics such as number of rooms, lot size, etc. In principle, if there are enough houses with different combinations of room size and lot size, it is possible to estimate an implicit price relationship. This relationship gives the price of any house as a function of the quantities of its various characteristics. The coefficients of the characteristics are the implicit prices.

A study of past research indicated that each residential property had unique characteristics which gave the properties their value. These characteristics included access, improvements, age of house, lot size, area of living space, and environmental factors. Some of the factors effected the value positively while others had an adverse effect. This study categorized the characteristics of residential property into four groups, illustrated by the general functional form:

$$MV = f(H_j, N_j, A_j, E_j) \tag{1}$$

where

MV = market value of the property (dollars sold in market),

H_j = physical housing characteristics j (e.g., age of house living space),

N_j = neighborhood characteristics j (e.g., availability of public services),

A_j = accessibility characteristics j (e.g., distance to major city), and

E_j = environmental characteristics j (e.g., water quality).

The variables used in this study specific to physical housing included lot size, area of living space, and age of house. Neighborhood factors included public services. These services consist of the availability of public water and sewer systems and quality of road adjacent to the property. Variables used to explain access included road distance to Spokane and distance to the nearest lake access. The final category in this model was environmental factors. These included water quality, water surface area of a lake, and average depth of lake. All of these variables are discussed in greater detail in Chapter IV.

The market sales method used market sales price as the dependent variable which included all market sales from January 1, 1978, to June 30, 1979. This method took the sales price at six different lakes, each with different water quality levels, and attempted to estimate the effect water quality, as well as other independent variables, had on property values.

Appraised Value Method

The appraised value method used the assessed values for the 1978-1979 county taxes as the dependent variable. In Washington all property is assessed at 100 percent market value. This method utilized the assessed value of the same properties found in the present sales method. Therefore, the same variables used in the present sales method were used here; the only difference being the dependent variable.

Personal Interview Method

The personal interview method determined the water quality effect by asking home owners at Liberty Lake how much they would buy or sell their property for with the present and a postulated improvement in water quality. The differences between the two buying or two selling prices is the estimated impact of a change in water quality. These differences, if unbiased, are a compensating variation (CV) measure of the welfare gain if the public good is provided in the specified quantity. The CV measure is often interpreted as the maximum amount that the individual would be willing to pay for the opportunity to consume at the new price. This study also recorded the home owner's response to questions regarding age of house, living space and lot size. These responses were compared to the assessor's worksheets to determine if there is a significant difference between the two. This analysis will help future surveyors decide which source to use when gathering physical housing information.

Hypothesized Relationships

An important hypothesis is that as the level of water quality increases so does the residential property value. If buyers and sellers are aware of these special environmental amenities, property value increases will reflect these beneficial impacts. It is assumed that there is an increment of the property value due to the presence of a lake and is positively related to the lake's water quality level. Since the increment in property value has been proven to exist and can be measured (Ridker 1967 and Darling 1973), this thesis will attempt to estimate that value using the three methods discussed in this chapter.

Statistical models designed to examine the hypothesized relationships are developed in the next chapter.

CHAPTER IV

EMPIRICAL PROCEDURES

Statistical Models

Market Sales and Appraised Value Methods

Since the market sales and appraised value methods differ only by dependent variables they were combined to describe the statistical models.

Building upon the economic models developed in the last chapter, multi-variable regression equations were derived. The models for explaining the market sales and appraised value methods were defined as follows:

$$MS \text{ or } AV = f(LISP, LSI, HYR, ASP, RDSP, ACC, QPR, WQ, WAS, ADL) \quad (2)$$

where

MS = actual market sales price of the residential property in 1978-1979 (dollars),

AV = 1978 assessed value of the residential property (dollars),

LISP = amount of living space (square feet),

LSI = lot size (square feet),

HYR = age of house (years),

APS = availability of public services (one if available, zero otherwise),

RDSP = road distance to Spokane from lake (miles),

ACC = distance from lot to access point on the lake (miles),

QPR = quality of public road next to the lot (one if paved, zero otherwise),

WQ = water quality of the lake at the time of the sale or assessment (subjective ranking of two to eight),

WSA = water surface area of the lake (acres), and

ADL = average depth of the lake (feet).

Multiple regression analysis was used in estimating the coefficients in the models. Regression analysis is a statistical tool which utilizes the relation between two or more quantitative variables, so that one variable can be predicted from the others. The quadratic and logarithmic functional forms were compared. The quadratic form assumed that the independent variables are completely independent, which may not be completely true. In making a decision to buy a house an individual may have used a combination of variables to make that decision. For example, the amount of living space may be related to the lot size or access to the lake may be correlated to the levels of water quality of the lake. These combinations or variables, known as interaction terms, were examined and are discussed more completely later in this chapter.

The logarithmic function implied that the independent variables have a multiplicative relationship. An assumption of this form stated that there is constant elasticity throughout the function. This assumption implies, for example, that a change from one to two in the water quality level will have the same effect as a water quality change from four to eight. This effect may or may not be constant.

No matter which regression function is used a random error always exists. This random error term, u is subject to the usual statistical assumptions. These assumption include, $E(u) = 0$, $E(uu') = \sigma^2 I_n$ and $u_i \sim N(0, \sigma^2)$ (Neter and Wasserman, 1974).

Discussion of Variables

Dependent Variables (MS, AV). The dependent variables were the 1978-1979 market sales (MS) and the 1978 assessed price (AV) of the same houses at six different lakes. The market sales and assessed prices included the complete unit of land, buildings, and other improvements, since real estate is generally bought and sold in this manner. All of these were recorded in dollars.

Records of the sales (amount, month, day and year) were obtained from the Sales Data File in the Spokane Assessors Office. The assessed price came from the 1978 Assessors Tax records also located in the Assessors Office.

Living Space (LISP). This variable measured the residence size. It was measured in square feet by county appraisers. The data came from the appraisal worksheets. This measure included all living areas in upper floors and/or basements, but excluded garages. The variable was expected to correlate positively with the price of the property. Thus as the amount of living space increased so should total value.

Lot Size (LSI). The second independent variable was lot size, expressed in square feet. This information was also collected from the assessor's worksheets. It was hypothesized that as the lot size increased so would the property value.

Age of House (HYR). It was assumed that as age increased so would the amount of repairs and the condition of the house would decrease. Therefore as the amount of repairs increased and the house condition decreased, property value would decrease. The information was obtained from the appraiser's worksheet and measured in years. It was hypothesized that age of the house would have an overall negative relationship with property values.

Availability of Public Services (APS). This variable identified which residences had access or were connected to a public or community sewer and water system. The variable was used to explain the variation of sale prices between houses with and without these services. It was a binary variable with one representing services available and zero representing services not available. Assessor's records were used to obtain this information. The variable was expected to have a positive relationship with property value.

Road Distance to Spokane (RDSP). Road distance, in miles to Spokane indicated the impact of access. The variable was thought to be important because of the city's social, economic, and governmental activities. Distance was measured from the lot to the center of Spokane using local road and highway maps. It was expected to have a negative correlation with property value.

Distance to Lake Access Point (ACC). This variable was measured from the residential property to the nearest legal lake access point (private or public) using plot maps obtained from the assessor's office. It was measured in miles. The variable was included because it was hypothesized that the reason a person bought in the area was because of the lake's attraction and activities offered. Therefore distance to access point was hypothesized to have a negative relationship with property value.

Quality of Public Road Adjacent to Lot (QPR). This variable measured the surface quality of public road next to the property. It was represented by a binary variable; one represented a paved road and zero represented other kinds. None of the properties were without road access. Measurement of this variable was done by personal observation. Quality of public roads is expected to have a positive correlation with the dependent variables.

Water Quality of Lake (WQ). In this study the water quality was measured using a subjective ranking similar to that of David (1968). The measure ranked six lakes on the basis of two individuals' perceptions of water quality who were familiar with the lakes. They were asked to rank the lakes on a scale of one to ten, ten being the best water quality condition. The actual ranking ranged from two to eight. This ranking was an overall condition of the lakes for the entire 1978 year and the first half of 1979. Water quality was hypothesized to be positively correlated with property value.

Water Surface Area of Lake (WSA). Use of this variable hypothesized that a larger lake is preferred to a smaller one. Size of lake was measured by acres of water surface area. The data were obtained from published reports dealing with these lakes (Funk, et.al., 1975; Eastern Washington Resort Association, 1974). A positive relationship was hypothesized between this variable and property value.

Average Depth of Lake (ADL). The average depth of each lake was measured in feet and was also obtained from published reports (Funk, et.al., 1975; Eastern Washington Resort Association, 1974). It was believed that if none of the lakes' characteristics were included in the regression the water quality variable would be explaining more than just water quality. Therefore water surface area and depth of lake were included to help explain the lakes characteristics. From observations taken at these lakes it was concluded that the main uses were fishing, swimming, and boating activities. These users tend to classify lake weeds as a deterrent of these activities (David, 1971). As the depth of a lake increases, it decreases the chances of lake weeds. Thus a positive relationship was hypothesized between this variable and property value.

Interaction Variables

The interaction terms used in this study were defined as the product of two existing explanatory variables into a linear regression equation (Kmenta, 1971). These terms were included since some interactions may be significant in the decision of buying, selling, or assessing a house. The variables examined were living space times age of house, access to the lake times water quality, water surface area times average depth of lake, water quality times water surface area, and water quality times average depth of lake. The combinations were selected because it was thought that these were the general combinations used by individuals in making a decision on purchasing property. Effects of each variable on property value were hypothesized as above. When combining two variables it is difficult to hypothesize the combined impact since the variables may have opposite effects on the dependent variable.

Personal Interview Method

From the three personal interview strategies to elicit recreational and/or aesthetic values discussed in Chapter III, the questionnaire form asking individuals their willingness to pay was used. The strategy that dealt with an individual responding to values proposed by the interviewer as being too high or low was believed to take too much of the interviewee's time. Another problem was that these types of bidding games can be subject to problems such as starting point bias (Randall and Brookshire, 1978). The strategy that dealt with allocation of a fixed budget tends to deal with several different levels of public goods. This was not used because it was determined that trying to explain more than one hypothetical water quality might be confusing to the interviewee. It was believed that the questionnaire bias of inducing respondents to provide distorted or biased information could be eliminated by using the open-ended willingness to pay questions.

Information from property owners surrounding Liberty Lake was obtained by a questionnaire. One question was how much they would pay for their property, assuming they were interested in buying it. Another question was how much they would sell their property for, assuming they were interested in selling. Each of these questions were asked twice, asking the prices at the present and at hypothetically improved water qualities. The differences of the two buying prices and selling prices were then tested to see if they were significantly different from each other. These differences were hypothesized to be the increased residential property value due to an increased water quality condition.

Other information obtained from property owners were age of house, lot size, and amount of living space. Responses from the questions were then compared to the same information obtained from the assessor's worksheets. The difference between the owner's response and assessor's record was also tested to see if it was significantly different from zero.

To test these hypotheses a pairwise t-statistic was used. Two-tail tests were used throughout. The t-statistic used was:

$$t = \frac{\bar{d} - D_0}{\sqrt{\frac{s_d^2}{n}}} \tag{3}$$

where

$$s_d^2 = s_1^2 + s_2^2 - 2rs_1s_2 \tag{4}$$

$\bar{d}$ = difference of the means between the two populations,

D_0 = hypothesized difference between the means (zero in this case),

s_d^2 = estimated variance of the difference,

n = sample size,

s_i^2 = i^{th} sample population variance,

s_1s_2 = sample population covariance, and

r = sample correlation coefficient.

Sampling Procedure

When setting up the sampling scheme it is suggested to review the study objectives, consider the populations to be sampled, divide the populations into sample units, and then select the sample (Cochran, 1977). The principal objectives were to determine the relationship between water quality and property values and compare the different methodologies.

The number of observations selected from each sample unit was determined next. Two factors were considered in determining sample size. These factors were the effects the sampling costs had on the study budget, and the acceptable limits of error in the sample estimates. Once the sample size was determined to produce satisfactory study results, cost changes due to larger or smaller sample size were considered. This change in cost was compared to the change in significance in the results to see if a different sample size was warranted.

Market Sales and Appraised Value Methods

The sampling unit included vacant and residential lots surrounding all six lakes for the present sales method and the assessed value methods.

A study of the sales data records revealed at the six study lakes there was a total of 275 sales in 1978-1979 (206 of the lots had houses and 69 were vacant). It was decided that the entire sample for the present sales method would be used. The reasons for this decision were that all the data could be obtained at the courthouse and was readily available, and the time spent collecting the information was short enough to warrant the increased significance.

The records also contained the assessed value of all properties for 1978. These assessed values were used in the appraisal method. Therefore, the sample size for the appraisal method was also 275.

Personal Interview Method

In the personal interview method the sample unit was all residential properties with houses at Liberty Lake. The interviewee was the head of the household. This included husband or wife, or both since together they may make up the decision unit.

In determining the sample size for this method an equation was needed that combined the sample size and the desired precision. Also, most equations require either the populations variance or a sample population variance in order to determine the sample size. Since the population variance was unknown and there were no past studies in this geographic area, a method to estimate the variance was needed. These restrictions resulted in the use of the following equation:

$$n = N\sigma^2 / [(N - 1)D + \sigma^2] \quad (5)$$

where

$D = B^2/4$,

n = sample size,

N = population size,

σ^2 = population variance estimated by $\sigma^2 = (\text{Range}/4)^2$ (Menderhall, et.al., 1971) where range - estimation of the range of housing values at Liberty Lake ($30,000 to $100,000), and

B = magnitude on the error of estimation.

The property value range was determined by looking at a sample of sales and assessed values and determined to be between $30,000 and $100,000. From this it was calculated that the variance was $(70,000/4)^2$ or 306,250,000. From the range it was also determined that the mean value of the property was $55,000.

Magnitude of the error of estimation, B, was calculated by taking the mean value of the property multiplied by the precision desired. For example, if the estimation was to be within five percent of the mean, B would be $55,000 x .05 or $2,750. This 2,750 is then used in determining D. The five percent level was adopted as the desired precision in this study.

The value of D would be $(2,750)^2/4$ or 1,890,625. Taking these values and placing them in the formula yields:

$$n = {}^{635(306,250,000)}/(634)(1,890,625) + 306,250,000$$

$$N = 129.2 \text{ or } 130$$

Appendix IV shows sample sizes for two, three, and ten percent levels of precision.

The population size of 635 was determined from the appraisers' lists of houses in the area surrounding Liberty Lake. A stratified random sample was drawn using county plot maps. Construction around the lake seemed to have been done in small neighborhood developments. These different neighborhoods could have different values of housing and/or people with different feelings of the lake's water quality condition. Thus a stratified random sample was used with the nine neighborhood developments as strata. Randomly starting in a corner of a stratum, every fifth house ($\frac{635}{130}$) was selected. This method resulted in an actual sample of 134. If the interviewer after three call backs (different days) could not get an interview the next house to the right was selected as a replacement. This actually occurred only seven times.

CHAPTER V

DATA ANALYSIS

In this chapter the present market sales, assessed value, and personal interview methods were analyzed. This analysis involved examining market sales and assessed value models using multiple regression in quadratic and double log forms. Relationships among variables and signs of the partial regression coefficients hypothesized at the start of the study were analyzed. Coefficients of multiple determination (R^2) were calculated and compared. From this work six revised equations were developed. These were the "best" estimates[1/] of the impacts of water quality changes on residential property values. Data from the personal interview method were compared using t-statistics. A few coefficients from each equation were examined to interpret the resulting change in the dependent variable with a change in the independent variable. This change was the result of altering one variable, while holding the other variables constant at their means. Similar analysis of the remaining coefficients could be done likewise.

Residential Properties With Houses

Market Sales Method

Quadratic Form. From the regression results the present sales method equation in quadratic form was:

1/ The best model was selected on the basis of goodness of fit (R^2) and the statistical significance of the independent variables.

$$\text{Sales Price} = \underset{(8766.92)}{24848.66} + \underset{(1.48)}{13.47}\,LISP + \underset{(4.1)}{1.23}\,WSA - \underset{(.12)}{.036}\,LSI \tag{6}$$

$$+ \underset{(2958.98)}{10035.84}\,APS + \underset{(376.55)}{392.40}\,RDSP - \underset{(8743.79)}{48481.55}\,ACC - \underset{(156.33)}{533.29}\,HYR$$

$$+ \underset{(7707.21)}{33413.82}\,ACC^2 + \underset{(1.78)}{4.38}\,HYR^2 + \underset{(686.02)}{950.20}\,WQ$$

$R^2 = .64$ d.f. = 195 $F = 32.35$

Numbers in the parentheses are standard errors of the coefficients

where

LISP = living space (square feet),

WSA = water surface area of lake (acres),

LSI = lot size (square feet),

APS = availability of public services (one if available, zero otherwise),

RDSP = road distance to Spokane (miles),

ACC = distance from lot to lake access point (miles),

HYR = age of house (years), and

WQ = lake water quality (ranking of two to eight).

When dealing with cross-sectional data, there is a chance that one can violate the ordinary least squares assumption of homoskedasticity. Homoskedasticity is where the variance of the error terms remains constant across all observations. The problems result in unbiased, consistent, but inefficient estimated parameters. This causes the estimated parameters to not have the minimum variance of the linear unbiased estimators (Hanushek and Jackson, 1977). Therefore, a test of this equation for homoskedasticity was made.

Visual observation was used to check for homoskedasticity. From the observations it was determined if the variance of the error terms varied with the independent variables. If a pattern is noted than there is a violation of homoskedasticity. All of the independent variables in Equation 6 were plotted individually against the residuals of their respective equations. Since no patterns were observed between the residuals and each of the independent variables, it was concluded that the homoskedasticity assumption was not violated and the estimated parameters were efficient.

In this equation 64 percent of the total variation in sales price was expalined by the independent variables. The F-value allowed the hypothesis that all $B_i = 0$ to be rejected.

The estimated coefficient of living space implies that with a ten percent increase from the mean, sales price will increase by $2,411, everything else remaining constant. This price converts to $13.47 per square foot. The coefficient is significant at the one percent level.

Age of house and age of house squared coefficients are -533.29 and 4.28. The house sage where sales price is the lowest is 60.9 years.[2/] A ten percent increase from the mean in the age of the house predicted a $1,255 decrease in sales price. The age of house coefficient is significant at the five percent level. The age of house squared coefficient is significant at the one percent level.

2/ This age was determined by taking a partial derivative of the equation with respect to age of house (∂ Property Value/∂ Age of House). The derivative was set equal to zero and solved for age. The second derivative with respect to age was positive which indicated that the property value is at a minimum at that point.

A move from four to five in the water quality scale results in a \$950 increase in sales price. The coefficient is significant at the 15 percent level.

In the above equation the coefficients of water surface area, lot size, and road distance to Spokane are not significant at the ten percent level.

Log Form. By similar regression analysis the log form of the present sales method was:

$$\text{Sales Price} = \underset{(1.00)(.062)}{(e^{7.7 + .21\ APS})} \ \underset{(.047)}{(LSI^{.013})} \ \underset{(.016)}{(ACC^{-.088})} \ \underset{(.047)}{(WSA^{-.028})} \quad (7)$$

$$\underset{(.13)}{(LISP^{.38})} \ \underset{(.15)}{(RDSP^{.25})} \ \underset{(.29)}{(HYR^{-.68})} \ \underset{(.064)}{(WQ^{.11})}$$

$R^2 = .69$ d.f. = 196 F = 48.19

The numbers in parentheses are standard errors of coefficients

In this equation the independent variables explained 69 percent of the total variation associated with the log of sales price. With the high F-value one can reject the hypothesis that all $B_i = 0$.

The results were checked for heteroskedasticity as discussed earlier in the chapter. No patterns between the residuals and independent variaables were observed. Thus, the estimated parameters were efficient.

In Equation 7 the functional form implied that the estimated coefficients are elasticities. Using this form assumes that the elasticities are constant throughout the entire data range. This implies that a change in water quality levels from one to two has the same effect as a change in water quality levels from four to eight.

In this equation the estimated coefficient of living space implies that with a ten percent increase sales price will increase by $1,755, holding everything else constant. On a square foot basis the price is $11.25. This coefficient is significant at the one percent level.

Moving from a water quality level four to five results in a $1,006 increase in sales price. In this equation the water quality coefficient is significant at the ten percent level.

The coefficients not significant at the ten percent level were lot size, water surface area, and road distance to Spokane.

Appraised Value Method

Quadratic Form. The following quadratic equation was selected using regression analysis for the appraised value method:

$$\text{Appraised Value} = \underset{(5629.1)}{7846.60} + \underset{(.95)}{8.41}\ LISP + \underset{(2.63)}{18.95}\ WSA - \underset{(.079)}{.014}\ LSI \qquad (8)$$

$$+ \underset{(1900.13)}{9426.42}\ APS - \underset{(241.8)}{51.04}\ RDSP - \underset{(5614.3)}{787.29}\ ACC - \underset{(100.39)}{544.58}\ HYR$$

$$- \underset{(4949.24)}{2206.06}\ ACC^2 + \underset{(1.14)}{3.56}\ HYR^2 + \underset{(440.53)}{221.40}\ WQ$$

$$R^2 = .78 \qquad d.f. = 195 \qquad F = 70.82$$

The numbers in parentheses are standard errors of the coefficients

The results were checked for heteroskedasticity as discussed earlier in the chapter. No patterns between the residuals and indpendent variables were observed. Therefore, the estimated parameters were efficient.

In this equation 78 percent of the total variation in appraised value was explained by the independent variables. The hypothesis that all

$B_i = 0$ was rejected due to the large F-value.

With a ten percent increase in the mean living space assessed value increases $1,505, holding everything else constant. This figure converts to $8.41 per square foot. The coefficient is significant at the one percent level.

In this equation the water surface area coefficient is significant at the one percent level. This relationship implies that a ten percent increase in the mean water surface area would increase assessed value by $1,171.

Age of house and age of house squared coefficients are -544.58 and 3.56 in Equation 8. The lowest assessed value is when age of the house is 77.9 years. Increasing the mean age by ten percent results in a $1,286 decrease in assessed value. Both coefficients are significant at the one percent level.

The water quality coefficient implies a positive relationship with the appraised value. Moving from a water quality index of four to five results in a $221 increase in the assessed value. The water quality coefficient is significant at the 40 percent level.

Again lot size and road distance to Spokane were not significant at the ten percent level in the above equation.

<u>Log Form</u>. The appraised value equation in log form using multiple regression analysis was:

$$\text{Appraised Value} = (e^{\underset{(.97)}{5.21} + \underset{(.061)}{.25}\,APS})\,(LSI^{\underset{(.045)}{.012}})\,(ACC^{\underset{(.016)}{-.052}}) \qquad (9)$$

$$(WSA^{\underset{(.046)}{.24}})\,(LISP^{\underset{(.12)}{.52}})\,(RDSP^{\underset{(.14)}{.049}})\,(HYR^{\underset{(.28)}{-.65}})\,(WQ^{\underset{(.062)}{.078}})$$

$R^2 = .84$ d.f. = 196 F = 114.85

The numbers in parentheses are standard errors of coefficients

In this equation 84 percent of the log of the appraised value variation was explained by the independent variables. With the high F-value it was possible to reject the hypothesis that all $B_i = 0$. No violation of the homoskedasticity assumption was found.

It again should be noted that Equation 9 implied that the estimated coefficients are in the form of elasticities. Therefore the same assumptions hold as discussed earlier in this chapter.

A ten percent increase in living space results in a $1,397 increase in the appraised value, holding everything else constant. This calculates out to $8.96 per square foot. The coefficient is significant at the one percent level.

The age of house coefficient is significant at the one percent level. This negative relationship implies that with a ten percent increase in the house's age the appraisal price will decrease by $1,721.

A change in the water quality index from a four to a five results in a $516 increase in the assessed price. The coefficient is significant at the 20 percent level.

Again all remaining coefficients can be examined in a similar fashion. Lot size and road distance to Spokane coefficients were not significant at the ten percent level.

Omitted Variables of the Market Sales and Appraised Value Methods

The variables omitted from the final models were quality of public road next to lot and average depth of lake.

Quality of public road next to the lot was omitted when it was determined that over 95 percent of the lots had a paved road next to them and the remaining roads were well graveled and oiled. In the regression model this variable had no significant relationship with the dependent variables, with a t-value of .034. When dropped from the models it had no significant effect on the other coefficients or the total fit of the model.

Average depth of the lake was deleted, due to a low t-value of .17. When deleted it had very little effect on the other coefficients or the total models.

None of the interaction terms were significant in any model. When eliminated they had no significant effect on the other coefficients.

Some variables remained in the models even though they were not significant at the ten percent level. These variables remained because theory suggested that they should be included to describe the dependent variable variations. The variables that remained were lot size, road distance to Spokane, and water surface area of the lake. There are some reasons why they might not be significant. Perhaps an individual in the market for a home is more interested in the type of dwelling than lot size. Also, the sample may not have enough lot size variation. The road distance and water surface area variables may not be significant because the sample size does not allow enough variation. Also the residents around the lakes may work in towns closer to the lakes rather than Spokane.

Comparison of Market Sales and Appraised Value Methods Coefficients

Table 1 allowed a comparison of dependent variable changes due to a variation of the independent variables. Distance to access point resulted in a large variation in the dependent variables. The estimated coefficients were all negative and ranged from -$139 to -$1,378. The coefficient

Table 1. A Comparison of the Dependent Variables Changes Due to a Variation of the Independent Variables for the Market Sales and Appraisal Value Methods at Liberty Lake, Washington, 1979.

	Method[a/]			
	Market Sales		Appraisal Value	
Independent Variable	Quadratic	Log	Quadratic	Log
Ten percent increase in living space				
Total effect	$2,411	$1,755	$1,505	$1,397
Per square foot effect	$ 13	$ 11	$ 8	$ 9
	(9.11)[b/]	(2.33)	(8.85)	(3.67)
Ten percent increase in lot size	$ 39 (-.29)	$ 59 (.27)	-$ 15 (-.18)	$ 32 (.26)
Ten percent increase in distance to access point	-$1,378 (c/)	-$ 402 (-5.48)	-$ 20 (d/)	-$ 139 (-3.30)
Ten percent increase in age of house	-$1,255 (c/)	-$3,090 (-2.70)	-$1,286 (c/)	-$1,721 (-2.59)
Ten percent increase in road distance to Spokane	$ 628 (1.04)	$1,143 (1.69)	-$ 82 (-.21)	$ 131 (.34)
Ten percent increase in water surface area	$ 75 (.30)	-$1,097 (-.59)	$1,171 (7.19)	$ 639 (5.18)
25 percent increase in water quality level	$ 950 (1.39)	$1,006 (1.71)	$ 221 (.50)	$ 516 (1.26)
Having available public services	$10,036 (3.39)	$9,598 (3.43)	$9,426 (4.96)	$6,659 (4.13)
R^2	.64	.69	.78	.84

a/ The independent variables were changed from the level of their means to a level ten percent higher than their means.

b/ Numbers in parenthesis are t-values for coefficients.

c/ Both linear and quadratic terms were significant at one percent level.

d/ Neither linear nor quadratic terms were significant at ten percent level.

in the quadratic appraised value method was not compared because it was not significant at the ten percent level. These coefficients had the same signs that were hypothesized earlier. The negative sign indicated that the property value decreased as the distance to lake shore increased.

The availability of public services had a positive relationship with the dependent variables, as hypothesized earlier. This implies that the property value increased between $6,659 and $10,036 when public services were available.

The effect the water quality variables had on the dependent variables also varied widely. Although three of the coefficients had t-values greater than one only one coefficient was significant at the ten percent level. The signs of the coefficients were all positive which indicated that as water quality increased so does the property value. The significant coefficient was found in the lograthmic form of the present sales method.

None of the effects lot size and road distance to Spokane had on the dependent variables were significant at the ten percent level, so no comparisons could be made.

A table of the independent variables' elasticities can be found in Appendix V. Elasticities is another way to compare the model's explanatory powers.

Personal Interview Method

Information obtained from the personal interviews and assessor's records was examined next. Using the t-statistics (Equation 3) discussed in Chapter IV several tests were conducted to examine the difference between the two selling prices and two buying prices, given different water quality levels.

The questionnaire used for this method is found in Appendix I.

Effect of Water Quality on Property Values

The people interviewed were asked four hypothetical questions. Given present lake conditions, how much would they pay for their property? Given present conditions of the lake, for how much would they sell their property? Given improved lake water quality, how much would they pay for their property? Given improved lake water quality, for how much would they sell their property? This was condensed for Table 2 to "buy now", "sell now", "buy after", and "sell after". The means, differences, and t-statistics can be found in Table 2.

There were differences between the individual's buying and selling prices. At the present water quality levels the difference equaled $8,861. The difference equaled $9,746 at improved water quality levels. Both of these differences were significant at the one percent level. The difference between the buying and selling prices at a certain water quality level could be caused by several factors. One was that the people who were interviewed may not be interested in moving. This implied that they would need an additional amount of money as an incentive to move. The other reason was people may buy and sell residential property as an investment as well as a place to live. Thus they would want to sell the property for a profit.

It was hypothesized that the differences between buy now and buy after and sell now and sell after would be two estimated measures of a water quality change. The differences between buy now and buy after was $4,795 and sell now and sell after was $5,679. Both these differences were significant at the one percent level. The differences between (buy now and after) and (sell now and after) were significant at the one percent level.

Table 2. The Means, Differences, and t-Statistics for the Buying and Selling Prices of Liberty Lake, Washington, Property as Computed from the Personal Interview Method, 1979.

n = 134		Mean		Mean
	Buy Now	$72,477.61	Sell Now	$81,338.81
	Buy After	$77,272.39	Sell After	$87,017.91

Difference Between	Mean Difference	Std. Error of Difference	T-value
Buy Now & Sell Now	$8,861.19	$819.32	10.82
Buy Now & Buy After	$7,794.78	$701.99	6.83
Sell Now & Sell After	$5,679.10	$820.00	6.93
Buy After & Sell After	$9,745.52	$892.05	10.92
(Buy Now & Buy After) & (Sell Now & Sell After)	$ 884.33	$281.22	3.14

The way in which the four questions were asked resulted in both differences ((buy now and after) and (sell now and after)) measuring compensated variation. Since the differences are significantly different from one another the question arises as to which figure is correct. The buying price difference tends to underestimate the impact, because buyers attempt to pay the lowest price possible. The selling price difference may overestimate the impact, because owners attempt to sell at the highest price possible. To prevent overestimating the impact water quality had on property value the buying difference ($4,795) was used here.

Comparison of Owner's Responses to Assessor's Records

The owner's estimate of lot size, living space, and age of house were compared to information on record at the courthouse. The means and differences are found in Table 3.

Table 3. Means, Differences, and t-Statistics of Living Space, Lot Size, and Age of House Obtained from Personal Interviews and Assessor's Records on Liberty Lake, Washington, Properties, 1979.

n = 95	Owner's Response	Assessor's Records	Difference	Std. Error of Difference	t-Stat.
Lot Size (sq. ft.)	10,956.07	11,266.8	310.73	455.42	.70
Living Space (sq. ft.)	1,935.53	2,104.52	168.99	60.41	2.79
Age of House	19.67	20.36	.68	.45	1.53

There was a significant difference between owner's and assessor's responses to living space, but no difference between age of house and lot size. The data suggest that property owners tend to underestimate the living space in their home, since appraisors were required to measure the amount of living space and the interviews were just estimates.

Properties Without Houses

Not all lots were developed. Separate equations using market sales and assessed value methods were used to estimate the impact of a water quality change on vacant lot values. Both a quadratic and logarithmic form were analyzed. The F-value was insignificant at the ten percent level using the log form. Variables in Equation 2 were used in these equations also. Variables associated with housing characteristics were excluded since there were no houses. Water surface area and road distance to Spokane were re-examined to determine if they had a curvi-linear relationship with the dependent variable.

Market Sales Method

Regression analysis was used to determine the equation for lots without houses.

$$\begin{aligned}\text{Sales Price} = {} & \underset{(10324.8)}{6256.93} + \underset{(.031)}{.16}\ \text{LSI} - \underset{(275.58)}{36.53}\ \text{RDSP} + \underset{(1472.48)}{3976.75}\ \text{APS} \\ & - \underset{(9672.8)}{21079.33}\ \text{ACC} + \underset{(13705.55)}{26004.96}\ \text{ACC}^2 - \underset{(52.18)}{11.59}\ \text{WSA} + \underset{(.049)}{.017}\ \text{WSA}^2 \\ & + \underset{(1120.88)}{139.40}\ \text{WQ}\end{aligned} \qquad (10)$$

$R^2 = .43$ d.f. = 60 F = 6.93

(Numbers in parentheses are standard errors of the coefficients)

Like the other four equations, these results were checked for heteroskedasticity. There were no patterns observed between the residuals and independent variables, thus the estimated parameters are efficient. Forty-eight percent of the present sales variation was explained by the independent variables. The hypothesis that all $B_i = 0$ was rejected at the five percent level.

The coefficient of lot size implies that for every additional square foot of land the sales price increases by $.16. The coefficient is significant at the one percent level.

The coefficient of distance to access on the lake implies a negative relationship with sales price. The coefficients for access and access squared are -21079.33 and 26004.96. These coefficients have the greatest effect on sales price at .41 of a mile. Both access and access squared variables are significant at the five percent level.

The water quality coefficient is 139.4. This implies that with a positive change from one level to another the sales price increased by $139.40. The coefficient is not significant at the 50 percent level.

Appraised Value Method

Regression analysis was also used in determining this equation for lots without houses. The equation was:

$$\text{Appraised Value} = \underset{(4306.82)}{12112.47} + \underset{(.012)}{.74}\ LSI - \underset{(516.67)}{1559.83}\ RDSP + \underset{(12.11)}{36.76}\ RDSP^2 \quad (11)$$

$$- \underset{(598.96)}{2747.41}\ APS - \underset{(3679.92)}{5779.34}\ ACC - \underset{(5214.13)}{7550.04}\ ACC^2 - \underset{(.0011)}{.0066}\ WSA^2 + \underset{(152.32)}{195.42}\ WQ$$

$R^2 = .68$ d.f. = 60 F = 15.91

(Numbers in parentheses are standard errors of the coefficients)

In this model 68 percent of the assessed value variation was explained by the independent variables. The hypothesis that all $B_i = 0$ was rejected at the one percent level.

The lot size coefficient indicates that for every additional square foot the assessed value increased by $.74. The coefficient is significant at the one percent level.

Road distance to Spokane variable implies a negative relationship with the appraised value. The distance that has the greatest effect on the appraised value is approximately 21 miles from Spokane. At 43 miles the effect road distance has on assessed value became positive. Even though both coefficients are significant at the one percent level, this positive relationship could be unrealistic because there are not enough samples points at the extreme high and low data range.

The coefficient of water quality implies a $195 increase in the appraised value due to a positive level change in water quality. The coefficient in this model is significant at the 20 percent level.

Comparison of Methodologies

In this section the market sales, appraised value and personal interview methods were compared. Results indicate water quality had a positive relationship with property values. In their present forms the relationships are difficult to compare. Therefore they were converted to a more comparable form. At the time of the personal interview the lake water quality had a ranking of four on the scale. The hypothetically improved conditions described to the individuals during the interview was closely related to a ranking of eight on the water quality scale. This then was an increase of four water quality levels in the linear equations and a 100 percent increase using the log equations. In Table 4 the effect of a change in this magnitude in water quality on property values is illustrated.

Table 4. The Effect a Water Quality Change from the Present to a Postulated Increase has on Property Values at Liberty Lake, Washington, 1978-1979.

Method of Estimation	Change in Property Value
Present Sales (quadratic)	$3,800
Appraised Value (quadratic)	884
Present Sales (log)	5,027[a/]
Appraised Value (log)	2,076[a/]
Personal Interview	
Difference between buy now and buy after	4,795
Difference between sell now and sell after	5,679
Present Sales Vacant Lots (quadratic)	556
Appraised Value Vacant Lots (quadratic)	780

a/ The average logarithm was used to compute this value.

Examining the t-statistics of the water quality change influence on property values showed that the quadratic market sales method change was significant at the 15 percent level. The appraised value quadratic change was significant at the 50 percent level. In the log functions the change in property values in the present sales and appraised value methods were significant at the 10 and 20 percent levels, respectively. The significant levels of influences of a change in water quality on property values of the quadratic market sales and appraised values methods for vacant lots were 70 and 20 percent, respectively.

In the personal interview method both differences [(buy now and after) and (sell now and after)] were significant at the one percent level.

Comparing the mean market sales price at Liberty Lake ($60,374) and the personal interview mean buying price at the present water quality ($72,477) a difference of $12,000 was found. With the personal interview method price being higher may indicate that the difference between the buy now and after overestimated the change in property value. The personal interview method mean selling price at the present water quality ($81,338) was also larger than the mean market sales. Thus, the difference between the sell now and after may too, overestimate the effect of a water quality change on property values.

The personal interview method took approximately 52 hours to interview all the home owners. An additional 24 hours were spent recording lot size, age of house, and living space area from the assessor's records. The interview method was not used on vacant lots, because of the increased time it would take to locate the owner and administer the questionnaire. Before the interviewing was done it was announced that Liberty Lake was going to be cleaned up and the first stage had been completed. Although lake weeds and algae were still a problem, the announcement may have had an impact on the responses during the interview. With this knowledge the individual could have pictured the lake complete cleaned, thinking that further cleaning was useless and indicate no difference in their buying and selling prices with a change in water quality. The results can also be biased by an individual who over or underestimates his willingness to buy or sell. A person who wants the water quality to improve could overstate his true feelings, hoping the overstated effect will influence the final decision or visa versa. Poor application caused by badly written or improper presentation of the questions could result in unusable results. The total impact water quality had on property values was at the high end of the results, but still comparable to the other methods used.

Present market sales were used as the dependent variable in the market sales method. It assumed that in the real estate market each sale was determined by the intersection of the demand and supply function for each residential property. Problems can arise if some sales were made to relatives or close friends. The sales price could be lower and does not show the real worth of the house or environmental qualities. Many sales and lakes with different water quality levels are needed for this method to function properly. This method took 54 hours to complete. Of the two functional forms, quadratic and logarithmic, the quadratic better explained the actual sales price. When the average logarithm of sales price is converted back to a sales price, it is approximately $5,000 less than the mean of the sales price. Therefore information is lost when making the conversion.

The appraised method used appraised value as the dependent variable. The appraised method was the assessor's interpretation of the market value and may not be as accurate as the sales method. The assessed value is generally less than the true market value, even though the lots are supposed to be assessed at 100 percent of market value. This problem was verified in Table 6 (Appendix II) where the lakes' mean sales price was greater than the mean assessed value. This problem may be eliminated with the use of a lag variable. Another problem was that the lakes' mean sales prices were different than the mean assessed values, this should not be since property is supposed to be assessed at 100 percent of the market value. A cause might be an industrial announcement of a new plant or shopping center being built nearby. In this case land prices are likely to increase more quickly than the assessed value. The difference between the mean sales prices and assessed values could have explained why the coefficients of some variables that are the same at one lake (water quality, water surface area, road distance to Spokane) but vary among lakes had a large variation between the appraised value and market sales methods. All appraisals are subject to some biases either political or otherwise. Even though it is not as accurate as the sales method this method may be used if there are not enough sales available to be analyzed. However, in order for this method to work, there must be several lakes with different water quality levels. The quadratic function is preferred over the logarithmic function for the same reasons discussed in the sales method. The appraised value method took about 50 hours to complete.

From the comparison it was believed that the market sales method described the relation between water quality and property value the best. This was because in the personal interview method there are numerous ways in which biases can appear no matter what is done to eliminate it. The appraised value method as discussed above tend to lag behind the actual market sales price, thus not capturing the true value of the property. So the effect of water quality on property values is most likely underestimated. The market sales method actually used what people payed for the houses at different water quality levels. Also, using these values eliminates almost all changes of any biases.

Community Impact

This study concludes that residential property increases as water quality increases. These findings can be extended and say that the entire community surrounding Liberty Lake could have an increase in the property value. This overall effect could range from $592,540 to $3,197,225 depending on which method was used. Table 5 compares the overall impact on the community due to an increase in water quality. This increase in water quality was from the subjective ranking of a four to the ranking of an eight.

This benefit added to all other benefits can be compared to the total cost of lake restoration to determine if the project is economically feasible.

Table 5. Overall Impact on the Liberty Lake Community Due to an Improved Water Quality Condition, 1979.[a/]

Methods	Total Value
Include Vacant Lots	
Present Sales[b/]	
Quadratic Form	$2,435,240
Log Form	$3,197,225
Appraised Value[b/]	
Quadratic Form	$ 592,540
Log Form	$1,315,860
Exclude Vacant Lots	
Personal Interview[c/]	$3,044,825

a/ The water quality improved from a ranking of a four to an eight on the scale discussed earlier.

b/ These were calculated using figures found in Table 4. There was a total of 635 houses and 40 vacant lots.

c/ These were calculated using the difference of the buying prices found in Table 4. There were 635 houses.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Study Application and Results

Eutrophication is the accelerated aging process of a lake which generally decreases the water quality in terms of aesthetic and recreational uses. The Environmental Protection Agency (EPA) staff is conducting extensive research on the physical and biological aspects of lake eutrophication. They are also researching technical and feasible methods to improve the water quality. Before these methods can be implemented they should be evaluated for economic feasibility. Economic feasibility implies that benefits exceed costs.

At Liberty Lake near Spokane, Washington, eutrophication has become a problem. The EPA is interested in the benefits that occur when the lake's water quality is improved. The benefits to the property owner were examined in this study. Three methods were compared and empirically tested to determine the economic benefits to property owners surrounding Liberty Lake. The comparison identified the strengths and weaknesses of the three models. The overall benefit to the property owners at Libery Lake from an improved water quality was calculated. For this study property was defined as the complete unit of land, buildings, and other improvements.

From previous research it was determined that the sales price, appraised value, and personal interview methods were to be evaluated. These methods were selected since they appeared to be conceptually sound and allowed future research to improve by identifying the strengths and weaknesses.

The present sales and appraised value methods used market sales from January 1, 1978, to June 30, 1979, and 1978-1979 appraised values for the dependent variables, respectively. The information was obtained from sales records and assessor's records located in the county courthouse. These methods took the sales price and appraised value at six different lakes, each with different water quality levels, and estimated the effect of water quality on property value. Two hundred and five properties were used in these methods. The dependent variables were regressed against several factors, including physical housing, neighborhood, accessibility, and environmental characteristics. A quadratic and double log function were examined. The results implied that water quality had a positive relationship with both sales price and appraised value. A 100 percent increase in water quality level caused a $3,800 or $4,035 increase in sales price per lot for the quadratic or log function, respectively. The same water quality increase resulted in a $884 or $2,076 increase in the appraised value for the quadratic or log function.

Several lots were vacant when the information was gathered. Therefore separate equations were estimated for these properties. The dependent variables were the same, but only neighborhood, accessibility, and environmental characteristics were used. Sixty-nine properties were utilized. From the results it was determined that a 100 percent increase in water quality would result in the sales price to increase by $556 per lot or the assessed price to increase by $195 per lot.

The personal interview method determined the water quality effect on property value. Home owners at Liberty Lake were asked how much they would be willing to buy and sell a particular home at different water quality levels. The differences between the two buying or selling prices were the estimated impact of a change in water quality. A stratified random sample of 134 property owners was taken at Liberty Lake. It was determined that the difference between the individual's buying prices and selling prices at different water quality levels was different from zero at the one percent level. The difference between the buying and selling prices due to different water quality levels were $4,795 and $5,679, respectively. Both the buying price difference and the selling prices difference tended to overestimate the water quality effect. The buying price difference was used when comparing the personal interview method to the other methods.

In several past studies (David, 1968; Schutjer and Hallberg, 1968; Coughlin and Hammer, 1973; and Boodt, 1973) road distance to the major city and lot size were found to be significant in explaining the dependent variable, market sales. Boodt (1978) also noted that the importance of accessibility was not as important as he originally thought. From this study it was found that the variables lot size and road distance to Spokane were not as important as the above studies reported when describing the dependent variables assessed value and present sales price. Access to the lake was important to this study which also contradicted Boodt's (1978) findings.

Examination of the data indicated that average lake depth and water surface area or a combination of these two were not a satisfactory indicator of environmental characteristics. Neither of these variables were as significant as originally perceived.

Study Limitations and Future Research Needs

In this research the theoretical framework explaining the environmental effects upon surrounding property values was examined. However, there were a few limitations. Some type of bias was found in the appraisal method. Since the appraisal value should be 100 percent of the market value an individual would expect the ranking of the different lakes mean assessed value and mean sales price to be the same. Examining Table 6 (Appendix II) it was found that the two rankings were not the same. Noting that this problem exists is about the only thing that can be done about this problem.

Determining a water quality index in the regression model was a problem. No real index of water quality has been developed. There is a need to develop some type of uniform water quality measure. For this study the subjective ranking done by individuals familiar with the lakes was the best available.

It had already been announced that Liberty Lake was going to be cleaned and the first stage had been completed before the personal interview was done. This may have had an impact on responses given during the personal interview. With this knowledge the individual could have pictured the lake complete cleaned. Anyone thinking that further cleaning was useless would indicate no difference in their buying or selling prices with a change in water quality. The interview should have been done before the actual lake restoration was started.

A limitation was the unequal sample sizes at different lakes for the present sales and appraised value methods. The lakes with larger samples may have too much influence on the regression results. A sampling scheme dealing with unequal cluster sizes would eliminate the problem.

BIBLIOGRAPHY

Barlowe, Raleigh. 1972. Land Resource Economics: The Economics of Real Property. Prentice-Hall Inc., Englewood Cliffs, New Jersey. 2nd Edition. 616 pp.

Boodt, William A., Jr. 1978. Effects of Reservoir Recreation Development Upon Rural Residential Property Values. Unpublished Ph.D. Thesis. Oregon State University. 542 pp.

Breton, Albert. 1974. The Economic Theory of Representative Government. Aldine Publishing Co., Chicago, Illinois. 228 pp.

Burby, Raymond J., III. 1971. "A Quantitative Analysis of Factors Influencing Residential Location in Reservoir Recreation Areas." Journal of Leisure Research. No. 3. pp. 69-80.

Cochran, William G. 1977. Sampling Techniques. John Wiley & Sons, Inc. New York. 3rd Edition. 428 pp.

Conner, J.C., K.C. Gibbs, and J.E. Reynolds. 1973. "The Effects of Water Frontage on Recreational Property Values." Journal of Leisure Research. Spring, No. 5, pp. 26-38.

Coughlin, Robert E. and Thomas R. Hammer. 1973. "Estimating the Benefits of Stream Valley and Open Space Preservation." Government Spending and Land Values. C.L. Harriss Ed. University of Wisconsin Press. Madison, Wisconsin. pp. 34-45.

Darling, Arthur H. 1973. "Measuring Benefits Generated by Urban Water Parks." Journal of Land Economics. Vol. 49, pp. 22-34.

David, Elizabeth L. 1968. "Lakeshore Property Values: A Guide to Public Investment in Recreation." Journal of Water Resource Research. Vol. 4. pp. 697-707.

David, Elizabeth L. and William B. Lord. 1969. "Determinants of Property Value on Artificial Lakes." Agricultural Economics Bulletin. May, No. 54.

Day, J.C. and J.R. Gilpin. 1974. "The Impact of Man-Made Lakes on Residential Property Values: A Case Study and Methodological Exploration." Journal of Water Resource Research. Vol. 10, No. 1. pp. 37-43.

Ditton, Robert B. and Thomas L. Goodale. 1973. "Water Quality Perception and Recreational Uses of Green Bay, Lake Michigan." Journal of Water Resource Research. Vol. 9, No. 3, pp. 569-579.

Eastern Washington Resort Assocation. 1974. Recreational Guide and Map. Inchelium, Washington. Pamphlet.

Freeman, A. Myrick III. 1979. The Benefits on Environmental Improvement: Theory and Practice. John Hopkins University Press, Baltimore, Maryland. 272 pp.

Funk, William H., Harry L. Gibbons, David A. Morency, Surinder K. Bhagaf, Gary C. Gailey, Jerry E. Ongerth, Donald Martin, and Paul J. Bennett. 1975. Determination, Extent, and Nature of Nonpoint Source Enrichment of Liberty Lake and Possible Treatment. Report No. 23, State of Washington Water Research Center, Pullman, Washington. 163 pp.

Hanushek, Eric A. and John E. Jackson. 1977. Statistical Method for Social Scientists. Academic Press, Inc., New York. 374 pp.

Kmenta, Jon. 1971. Elements of Econometrics. MacMillan Publishing Co., Inc. New York. 655 pp.

Knetsch, Jack L. 1964. "The Influence of Reservoir Projects on Land Values." Journal of Farm Economics. No. 46. pp. 231-243.

Mann, W. Merle and Jack K. Mann. 1968. "Analysis of the Influence of the Pearl River Reservoir on Land Prices in the Area." The Appraisal Journal. January. pp. 42-52.

Mendenhall, William, Lyman Ott, and Richard L. Scheaffer. 1971. Elementary Survey Sampling. Duxberry Press. Belmont, California. 247 pp.

Neter, John and William Wasserman. 1974. Applied Linear Statistical Models. Richard D. Irwin, Inc. Homewood, Illinois. 842 pp.

Randall, Alan and David S. Brookshire. 1978. Public Policy, Public Goods and Contingent Valuation Mechanisms. Staff Paper 68. Department of Agricultural Economics, University of Kentucky, Lexington, Kentucky. 37 pp.

Ridker, Ronald G. 1967. Economic Costs of Air Pollution: Studies in Measurement. Praeger, New York. 202 pp.

Schutjer, W.A. and M.C. Hallberg. 1968. "Impact of Water Recreational Development on Rural Property Values." American Journal of Agricultural Economics. Vol. 50. pp. 572-583.

Simmons, I.G. 1974. The Ecology of Natural Resources. Halsted Press. New York. 424 pp.

APPENDIX I

OREGON STATE UNIVERSITY
Resource Economics Program
Property Value Study Date____________

Lot Identification No. ________

INTRODUCTION: Hello, I am ____________, a student from Oregon State University. We are working on a property value study on some lakes surrounding Spokane. We are trying to determine what affect water quality has on the value of residential property. We would like to ask you a few questions about your property. All answers will be kept strictly confidential. The results are tabulated for the area as a whole, not for any one person.

1. How long have you lived in this house? __________________

2. What is the age of your house? ________________________

3. How many square feet of living space does your house have? __________

4. What is the size of your lot? ____________________

5. What is your impression of the water quality at Liberty Lake? (Interviewer: Not at any specific time, but in general)

   Is it: Excellent Good Fair Poor

These next questions are only hypothetical; please keep that in mind when answering them.

6. Given the present water quality conditions of Liberty Lake and assuming you were in the market for a home today, how much would you pay for this house and lot? ____________________________

7. Now keeping in mind we are talking about the present conditions of the Lake, if you were to put this house and lot on the market today, how much would you sell it for? _____________________

8. Now suppose for a moment that the water quality at Liberty Lake was significantly improved, that is, if there were an annual algae blooms or lake weed build-up, how much would you pay for this house and lot? __________________

9. Given those same lake conditions, if you were to put this house on the market, how much would you sell if for? _________________________

APPENDIX II

Table 6. Averages of Variables for Property With Houses Used in Present Sales and Appraised Value Methods for Liberty Lake, Washington, Study, 1979.

	Medical Lake	Newman Lake	Liberty Lake	Badger Lake	Silver Lake	Clear Lake	Overall
Number of Cases	51	33	95	1	17	9	206
Sales Price	$43,298	$31,699	$60,374	$45,000	$47,487	$68,717	$50,799
Log of Sales Price	10.54	10.23	10.97	10.71	10.72	11.12	10.73
Appraised Value	$22,476	$14,552	$44,105	$10,800	$28,288	$35,212	$32,161
Log of Appraised Value	9.78	9.49	10.64	9.29	10.19	10.41	10.19
Living Space	1,591	883	2,216	672	1,784	2,113	1,792
Log of Living Space	7.24	6.63	7.64	6.51	7.41	7.53	7.35
Lot Size	9,471	8,483	12,694	9,000	100,764	10,759	10,960
Log of Lot Size	9.09	8.91	9.31	9.11	9.25	9.15	9.18
Age of House	33	49	15	21	8	14	24
Log of Age of House	2.94	3.81	1.76	2.05	1.89	1.43	2.69
Road Distance to Spokane	13	23	15	32	14	22	16
Log of Road Distance to Spokane	2.57	3.14	2.71	3.47	2.64	3.09	2.76
Distance to Access Point on Lake	.47	.058	.29	.01	.30	.10	.29
Log of Distance to Access Point on Lake	-1.1	-3.72	-1.92	-4.61	-1.95	-2.48	-2.04
Water Surface Area	207	932	781	249	500	350	618
Log of Water Surface Area	5.33	6.84	6.66	5.52	6.22	5.86	6.28
Water Quality	2	3	4	6	7	8	3.71
Log of Water Quality	.69	1.1	1.39	1.79	1.95	2.08	1.25
Availability of Public Services	Yes	No	Yes	No	No	Yes	----
Log of Interaction Term (Living Space & Age of House)	21.1	25.18	13.18	19.82	13.87	18.29	17.37

APPENDIX III

Table 7. Averages of Variables for Vacant Lots Used in Market Sales and Appraised Value Methods For Liberty Lake, Washington, Study, 1979.

	Medical Lake	Newman Lake	Liberty Lake	Badger Lake	Silver Lake	Clear Lake	Overall
Number of Cases	13	4	26	3	17	6	69
Sales Price	$6,884	$10,250	$11,481	$7,500	$6,124	$6,500	$8,618
Apprasied Value	$1,458	$ 2,625	$ 5,138	$3,033	$1,394	$ 297	$2,864
Lot Size	10,304	13,338	17,198	22,587	18,888	4,350	15,209
Road Distance to Spokane	13	23	15	32	14	22	16
Distance to Access on Lake	.40	.08	.24	.01	.24	.17	.25
Water Quality	2	3	4	6	7	8	4.74
Water Surface Area	207	932	781	249	500	350	552
Availability of Public Services	Yes	No	Yes	No	No	Yes	---

APPENDIX IV

Determining Sample Size for Personal Interview

Method at Liberty Lake

$$n = {}^{N\sigma^2}/(N-1)(D) + \sigma^2 \qquad D = {}^{B^2}/4 \qquad \sigma^2 = ({}^{Range}/4)^2$$

N = 635

Range in assessed value: 100,000 - 30,000 = 70,000

$$\sigma^2 = \left(\frac{70,000}{4}\right)^2 = 306,250,000$$

Mean assessed value = $55,000

Want estimate within two percent:

B = 1,100 D = 302,500 n = 390

Want estimate within three percent:

B = 1,650 D = 680,625 n = 264

Want estimate within ten percent:

B = 5,500 D = 7,562,500 n = 38

APPENDIX V

Table 8. Elasticities of Dependent Variables for Market Sales and Appraised Value Methods with Houses at Liberty Lake, Washington, 1979.

	Method			
	Market Sales		Appraisal Value	
Variable	Quadratic	Log	Quadratic	Log
Living Space	.48 (9.11)[a/]	.47 (2.33)	.38 (8.85)	.52 (3.67)
Lot Size	-.0077 (-.29)	-.0048 (-.27)	-.013 (-.18)	.012 (.26)
Water Surface Area	.015 (.30)	-.36 (-.59)	.028 (7.19)	.24 (5.18)
Availability of Public Services	.15 (3.39)	.22 (3.43)	.21 (4.96)	.25 (4.13)
Road Distance to Spokane	.12 (1.04)	.026 (1.69)	-.25 (-.21)	.049 (.34)
Distance to Access Point	-.27 (-5.55)	-.0070 (-5.48)	-.088 (-.14)	-.052 (-3.30)
Distance to Access Point Squared	.11 (4.34)		-.011 (-.45)	
Age of House	-.26 (-3.41)	-.41 (-2.70)	-.68 (-5.42)	-.65 (-2.59)
Age of House Squared	.11 (2.46)		.14 (3.11)	
Water Quality	.071 (1.39)	.026 (1.71)	.11 (.50)	.078 (1.26)

[a/] Numbers in parenthesis are t-values for coefficients.