Non-Market Valuation of Water in Residential Uses

By

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ABSTRACT

Increases in water demands were historically met through the augmentation of water supply facilities. However, the most easily developed water sources have already been tapped, and water pollution adds to the cost of developing some water sources.

Given the increased cost and difficulty of water supply augmentation, more attention has been given recently to demand management. This requires the assigning of priorities to water uses, and the subsequent fulfillment of only the most highly valued needs. In 1978 the U.S. National Water Commission directed that the most highly valued needs be determined through the concept of consumers' willingness to pay for publicly supplied water.

This research is designed to test the use of a non-market valuation technique to assess the residential consumers' willingness to pay for household water. It was hypothesized that the willingness to pay would be dependent upon a consumer's income, family size, the amount of water used, the presence of a well, and also upon variables representing a consumer's beliefs and attitudes concerning local water scarcity and conservation. Results indicated that indeed most of these variables did play a role in the formulation of a willingness to pay for residential water. Some inconsistencies in results, however, indicate that more research is required before non-market valuation techniques can be applied with confidence to residential water demand analysis.

CHAPTER I

INTRODUCTION

The Problem Setting

Studies on demand reductions have been prompted nationwide by the realization that water supply systems will be increasingly pressured both by natural drawdowns and also by the environmental objections to a proliferation of water projects which are not considered to be ecologically sound. Measures taken by a water utility to conserve water through demand reduction are relatively recent. The most extensive research on consumer response to water shortages has taken place in California following the drought seasons of 1976-77.

The California drought of 1976-77 gave impetus to water research in demand management. Precipitation in both years averaged less than one-half of normal levels and the compounded effect had vast consequences for the state's water supply systems. Accommodating the problem from the supply side involved supply enhancement methods, which are generally unsuccessful at such short notice, and interdistrict transfers which were exceeding costly and politically unpopular. Demand reduction policies proved to be far more effective. Accomplished principally through rationing, the overall average demand reduction through the state for the summer of 1977 was 49% (Hoffman, et al., 1979).

Earlier, in 1966 a drought in the Potomac area of Washington, D.C., sparked studies by the Washington Suburban Sanitary Commission (WSSC) which culminated in a conservation program. Between the years 1980 and 2000 the demand for water in the D.C. area given population growth and per capita use rates, is expected to far outstrip the potential supply and sewer capabilities. The pursuit of regional solutions by supply augmentation was discouraged until a conservation program was put into effect. The resulting program, consisting of a public education program, a revised building and plumbing code, and a conservation rate structure, was able to reduce residential consumption by 13.8% through the 1970's (McGarry and Brusnighan, 1979).

In Florida, water shortages result from intense urbanization in the relatively water scarce parts of the state. Of Florida's nine million residents, nearly 75% reside in the coastal zone. Compounding this effect are the water demands caused by the state's annual 25 million tourists who are attracted to the shoreline areas where water is far less plentiful than inland (Bureau of Coastal Zone Management, 1979). The subsequent groundwater drafts have caused excessive watertable drawdowns. In some areas, such as Jacksonville and Tampa-St. Petersburg, the resulting salt water intrusion has threatened both current and potential well sources (Parker, 1975).

Natural shortages are not the only source of difficulty facing efforts to augment water supplies. Environmental pressure groups have lobbied consistently for the reconsideration of funding for water supply infrastructure. They contend that the costs of the environmental damage to natural settings outweigh the benefits of fulfilling the growing water demand of urbanization (Sierra Club, 1980). The political weight carried by environmentalists was made manifest in 1977 when President Carter deleted federal funds for 18 major federal water projects (Schlerger and Cerviso, 1980). This provided a catalyst for the implementation of a new national water policy establishing stringent environmental criteria for future projects. Announced in June, 1978, the new national water policy specifically directed that water conservation be added to the Principles and Standards of the Water Resources Council which evaluates all federally constructed projects (Schad, 1978). Thus it was required that all federal agencies with water programs advocate conservation and integrate it into all program planning.

In response to nationwide water shortages and environmental objections to water supply development projects, water conservation and the water demand management that it necessitates, has become a national objective. Residential demand for water has been the subject of several economic analyses.[1] Water demand studies have reported coefficients relating quantity of water demanded by the residential sector to price, and to a number of nonprice variables including household size, household income, property size, property value, and climate (Andrews, 1974; Clouser and Miller, 1979; Danielson, 1977; Gottlieb, 1963; Hanke, 1970; Headley, 1963; Hogarty and Mackay, 1975; Lineaweaver, et al., 1966; Lynne and Gibbs, 1976; Morgan, 1973; North, 1967; and Wong, 1972). The development of water management policies has benefited from the knowledge gained by these studies.

Water demand studies have typically relied upon secondary sources of data, using statistical inference to test hypotheses about relationships among variables associated with residential water demand. Available data from secondary sources generally does not permit the refinement of analysis to include effects on non-marginal price changes, differentiation among components of household water demand, and the influence of attitudes, knowledge and beliefs on residential water demand and valuation.

As a consequence, residential water demand models statistically are typically not designed to yield information on the social valuation of residential water use. They are therefore limited in usefulness for several types of policy evaluations:

(1) They are not well suited to evaluate policies which contemplate dramatic changes in water rates, never before experienced by users and therefore outside the range of existing data; or regulatory reductions in water allocated to the residential sector.

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[1]The word "demand" is used by different people to mean different things. In economics, demand is a technical term referring to the amount of a commodity that would be purchased at a given price (Lauria, 1975). In the case of water for residential uses, price of water is a key determinant of quantity demanded, given the influence of other variables such as per capita household income, the preferences of people with respect to green lawns, daily showers, swimming pools, and other variables. The point is, the economic concept of demand views demand as a variable, associated in predictable ways with the combined influences of other identifiable variables. By contrast, the terms "requirements" or "needs," often used interchangeably with the word demand, are, in fact, mere expressions of unexplained and unqualified desires for a commodity, conveying no information about their determinants.

(2) They do not disaggregate household water demand beyond the distinction between domestic (in-house) and sprinkling (outdoor) demand, and are to that extent not well suited to evaluation of policies directed at influencing specific household uses of water.

(3) They do not generally permit assessment of the manner in which "taste-like" variables such as beliefs, knowledge, and attitudes relate to demand for, and valuation of, residential water use, and are not well suited to evaluation of public education programs designed to influence rates of water use.

The Research Problem

Whether water policy emphasizes water supply development or demand management, there exists a need for detailed information about the welfare effect on people when limitations are placed on household uses of water. The concept of a consumer's "willingness-to-pay" for residential water was adopted by the National Water Commission in 1973 to direct allocation of water resources (Schad, 1978). The determination of this benefit measure has not been previously researched in residential water demand analysis.

Objectives of Research

The overall objective of this research is to adapt and apply a methodology for eliciting consumers' valuations of nonmarket goods to the measurement of consumers' valuations of water in residential uses. Specific objectives include:

(1) measurement of consumers' valuations of the loss in utility associated with specified reductions in the amount of water permitted for specified residential uses;

(2) identification of the major determinants of consumers' valuations of water in residential uses; and

(3) quantification of the relationship between consumers' beliefs and attitudes about water conservation, and their valuation of water in specified residential uses.

Method of Procedure

Valuation, for purposes of benefit/cost analysis, is an attempt to ascertain the quantity of money which gainers and losers from some proposed action will consider equivalent in value to their respective gains and losses (Randall and Brookshire, 1978). Non-market valuation mechanisms, some of which are called contingent market valuation mechanisms, elicit valuations of non-market goods by establishing hypothetical markets and recording the contingent decisions of individuals confronted with special changes in these hypothetical markets. Non-market valuation techniques differ from more conventional demand analysis in their reliance upon primary data rather than secondary data.

A method of contingent market valuation called iterative bidding will be used in this study. In this valuation procedure, a hypothetical market is described and defined in detail (Randall and Brookshire, 1978). Alternative levels of provision of the good are described. The institutional details pertaining to method of payment and enforcement of terms are explained. An enumerator then poses prices to which the respondent reacts, indicating whether he would pay the price or go without the good. The price is varied iteratively until the price at which the respondent is indifferent is identified. The process is repeated for several levels of provision of the good.

For this study, representative samples of residential water customers will be drawn from two major cities in Florida. Consumers will be visited by an interviewer and confronted with a hypothetical situation in which the water utility, because of growth in water demand and shortages of raw water supplies, must either enforce a highly selective rationing plan or else raise utility bills in order to finance expansion in water supply capacity. Consumers are then asked, through an iterative questioning procedure, to reveal their maximum willingness to pay to avoid the specified reduction in water use. The procedure will be repeated for contingencies involving successively larger reductions in water use. In this manner, a measure of willingness to pay to avoid each of several decrements in water use will be obtained. A second set of questions present a scenario in which the consumer is entitled to his current level of water use and will elicit the amount of compensation necessary in order to induce the consumer to willingly accept specified decrements in level of water use. In this manner, a measure of willingness to accept compensation for each of several decrements in water use can be derived. Payments and compensations will be considered in the form of the total water bill. Separate information about household income, household size, attitudes concerning water conservation and other, similar variables will be obtained. Multiple regression analysis will be used in order to test for statistically significant relationships between the amount of bid (e.g., willingness to pay) and variables normally associated with demand for residential water.

CHAPTER II

CONSUMER'S SURPLUS AND VALUATION OF BENEFITS

Benefit Estimation

The objective of benefit-cost analysis is to direct the usage of goods, services, or resources to their most highly valued employment. Thus the measurement of values imputed by consumers to goods and services has as its ultimate purpose the economically efficient allocation of resources.[2] Non-market valuation methods have been developed for purposes of estimating benefits and costs pertaining to provision of goods, services, and resources for which established price-quantity data are not available.

Consumer net benefits from a current or proposed resource allocation are defined and measured with the assistance of a theoretical concept called the consumer's surplus. The concept of consumer's surplus has theoretical underpinnings in the assumptions about consumer behavior of the neoclassical economists.

Neoclassical Assumptions About Consumer Behavior

Utility Maximization

Consumers are presumed to make rational choices as to the level and mix of goods and services they consume, with the objective of maximizing their individually and subjectively perceived levels of satisfaction or utility (Henderson and Quandt, 1971). Each consumer has, theoretically, an indifference map for any combination of goods. He also has an income constraint which limits the range of combinations, from the indifference map, which he can afford to consume (given positive prices for the goods and services). Assuming decreasing marginal rates of substitution among goods and services, and assuming increases in consumption produce increases in subjectively experienced utility, the rational consumer will allocate his limited income among the goods and services in a manner which maximizes his utility.

Demand Functions

Given the assumptions about consumer behavior, the quantity of a good demanded per time period is a function of the price of that good,

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[2]Conceptually, economic efficiency is achieved if the allocation of resources for production and consumption is Pareto optimal--a state achieved if no reallocation of resources to improve the welfare of one individual can be made without reducing the welfare of one or more other individuals (see Henderson and Quandt, 1971, for a summary).

the price of substitutes (or complements), the consumer's income, and those aspects of beliefs, tastes, and preferences which underlie the consumer's indifference map. Demand functions are mathematical formulations which express the form and magnitude of the relationship between quantity demanded, the dependent variable, and the relevant independent or explanatory variables.

The Consumer's Surplus

Consumer's surplus is an important concept in the measurement of social benefits in any social cost-benefit calculation (Mishan, 1976). A simple definition of consumer's surplus is: the maximum sum of money a consumer would be willing to pay for a given amount of a good, less the amount he actually pays. By this definition, the market price in a perfectly competitive market is an adequate index of the value of a marginal change in quantity of a good, but is not an adequate measure of larger quantities of a good. In terms of the demand curve, beginning from a given amount of the good offered on the market, the corresponding point on the demand curve indicates the maximum price the average consumer is willing to pay for the last unit of that amount. But to each of the total number of units purchased, as measured along the quantity axis, there corresponds some average maximum valuation. The whole area under the demand curve, therefore, corresponds to society's maximum valuation for the quantity in question. Consumer's surplus is that portion of the area under the demand curve above the price line.

In statistical estimates of the price-quantity relationship represented by the demand curve, other variables known to influence quantity demanded will be held (or assumed) constant (Mishan, 1976). However, if aggregate money income is held constant in estimation of the demand function, any fall in the price of the good raises real income. This increase in real income will cause some increase (if the income effect is positive) in the amount of the good purchased in addition to that increase in quantity representing substitution of the good for some other in response to the change in relative prices.

Hicks (1941) redefined the concept of consumer's surplus, using an ordinal system of indifference curves, as the amount of money--to be paid by the consumer when the price falls; to be received by him when the price rises--which, following a price change, leaves him at his original level of welfare. This measure of consumer's surplus allows the consumer to readjust the mix of goods which he consumes following the price change.

Henderson (1941) pointed out that, in general, the relevant compensating variation in income would depend on whether the consumer had to pay for the priviledge of buying the new good or whether he was to be paid for not being able to buy the good.

Subsequently, Hicks (1941) defined four measures of the change in consumer's welfare resulting from an actual or proposed price change. These four measures, summarized, are as follows:

(1) "Compensating variation" is the amount of compensation, paid or received, that will leave the consumer in his initial welfare position following the change in price if he is free to buy any quantity of the commodity at the new price.

(2) "Compensating surplus" is the amount of compensation, paid or received, that will leave the consumer in his initial welfare position following the change in price if he is constrained to buy at the new price the quantity he would have bought at that price in the absence of compensation.

(3) "Equivalent variation" is the amount of compensation, paid or received, that will leave the consumer in his subsequent welfare position in the absence of the price change if he is free to buy any quantity of the commodity at the old price.

(4) "Equivalent surplus" is the amount of compensation, paid or received, that will leave him in his subsequent welfare position in the absence of the price change if he is constrained to buy at the old price the quantity he would have bought at that price in the absence of compensation.

The decision as to which measure is appropriate for a particular analysis depends upon the specific nature of the proposed change for which benefits and costs are to be measured. HIcks' four measures pertain to goods, priced in competitive markets, for which price and quantity data are available. Benefit estimation in the context of nonmarket, unpriced, or underpriced goods required adaptation of the consumer's surplus concept to make it applicable in quantity change analysis as well as in price change analysis.

Consumer's Surplus: Quantity Change Analysis

In benefit-cost analysis, the economist is sometimes concerned not so much with the welfare impacts of price changes as with the welfare impacts of changes in the bundle of goods, services and amenitites possessed, used or consumed by individuals (Randall and Stoll, 1980). Proposed projects or programs may remove some goods from individual opportunity sets or introduce new goods; and may decrease the quantities of some goods while increasing quantities of others.

The goods affected by proposed programs may be divisible, exclusive, marketed goods with observed prices. However, they may also be recreational or environmental amenities or other goods which are in varying degrees indivisible, non-exclusive, and unpriced (Randall and Stoll, 1980).

Randall and Stoll (1980) identify the conditions under which consumer's surplus measures can be adapted to situations in which it is bundles of goods, rather than prices, which are changed. Their diagrammatic exposition (Figure 1) proceeds as follows.

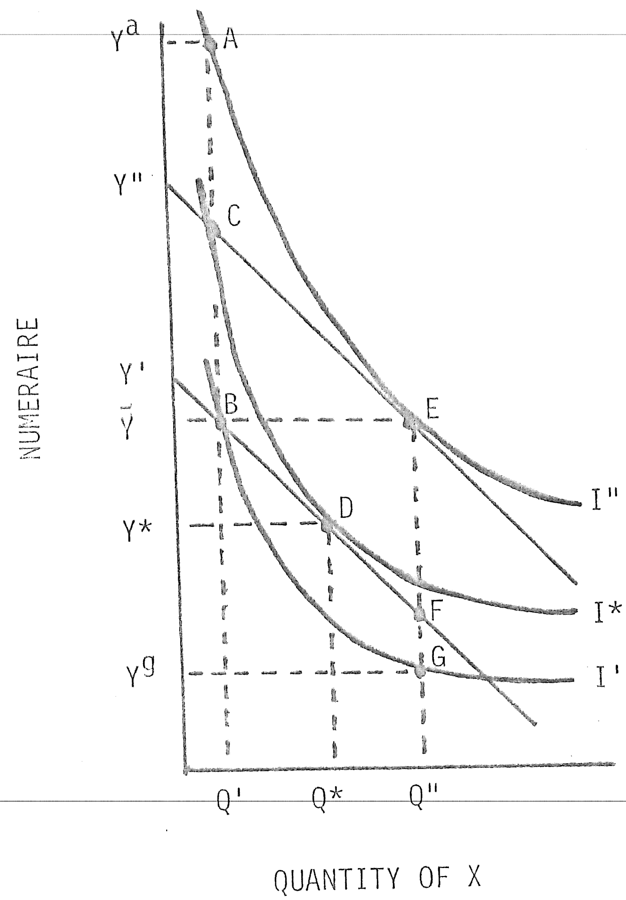

Figure 1.--The welfare impact of a change in the quantity of a good X from Q" to Q'.

Consider a normal good X, which, depending on the program alternatives chosen, may be provided in two different quantities, Q' and Q", where Q" is greater and ceterus paribus preferred. The pragmatic measures of value of these two bundles of goods are willingness to pay (WTP) and willingness to accept (WTA). In a market exchange situation these correspond, respectively, to the buyer's best offer and the seller's reservation price; in a nonmarket situation, they correspond to willingness-to-pay and willingness-to-accept compensation (Randall and Stoll, 1980).

If the program alternative under evaluation would reduce the quantity of X from Q" to Q', the compensating measure of welfare loss is WTA^C, the compensation which would keep the individual at his initial welfare level; and the equivalent measure is WTP^E, the loser's willingness to pay to avoid the quantity reduction from Q" to Q' which, if paid, would place the individual at his subsequent welfare level (Randall and Stoll, 1980). If the proposed program would increase the quantity of X from Q' to Q", the compensating measure of welfare gain is WTP^C which, if paid, would keep the gainer at his initial welfare level; and the equivalent measure is WTA^E, the compensation which would be needed to bring the potential gainer to his subsequent welfare level in the event that the proposed program is not implemented (Randall and Stoll, 1980).

If X were a perfectly divisible good, traded in large markets at zero transactions costs, a program to reduce Q" to Q' while leaving the individual's numeraire, Y (a composite of "all other goods"), at $\bar{Y}$ would initially move the individual from point E to B (Figure 1), lowering his welfare level from I" to I' (Randall and Stoll, 1980). However, the existence of frictionless markets will permit him to trade along his new budget line until he reaches D, achieving the welfare level of I*. Given this adjustment, his WTP^E is EF, equal to Y" Y', while his WTA^C is BC, equal to Y'Y". Thus, WTP^E is equal to WTA^C.

Now, assume that X is lumpy and can only be held in the amounts Q" and Q'. Since intermediate adjustments in commodity holdings are not permissable, the Hicksian compensating and equivalent measures in commodity space are analogous to the Hicksian surpluses, not the variations, defined over price changes (Randall and Stoll, 1980). Accordingly, the price lines (Figure 1) become meaningless. WTP^E is EG which is equal to $Y^g\bar{Y}$, and WTA^C is BA, which is equal to $\bar{Y}Y^a$, and larger in absolute value than WTP^E.

In identifying the appropriate measure of welfare change, several distinctions among the Hicksian measures must be clarified (Brookshire, et al., 1980):

(1) The Hicksian compensating and equivalent measures of consumer's surplus differ with respect to the reference level of welfare. The compensating measure, by using the initial welfare level as the reference level, measures the welfare impact of changes as if the individual had a right to his initial level of welfare. The equivalent measure, by using the subsequent welfare level as the reference level, treats the individual as if he had a right only to his subsequent level of welfare.

(2) The Hicksian variations differ from Hicksian surpluses in that variations are calculated after the consumer has made optimizing adjustments in his consumption set, while surpluses are calculated without first allowing such adjustments.

CHAPTER III

NON MARKET VALUATION: THE ITERATIVE BID

Non-Market Valuation Method

Measures of value for goods and services traded or sold in private markets are typically derived from market-generated price-quantity information. In the case of public goods, and publicly provided goods, valuation methods must be devised which emulate the market process or in some other manner generate information from which measures of value can be derived.

Non-market valuation methods have been applied in benefit estimation studies of environmental improvements, the creation or improvement of recreation sites, and the provision of wildlife. These methods fall into two general categores: the proxy methods and the bid game methods.

Proxy methods require the choice of variables upon which quantifiable observations can be made (i.e., for which data exist) and which are hypothesized to be highly correlated with the price (or other) variable for which data do not exist. An example of the proxy method is the use of measurable travel costs as a proxy measure of the willingness of recreationists to pay for the composite of experiences associated with a particular recreational activity, taking into account other explanatory variables such as income, substitutability of other recreation sites, and individual tastes (see, Sinden, 1973).

The bid game method was pioneered by Robert K. Davis (1963) who used it to estimate the benefits of maintaining New England wilderness areas. The bid game method elicits direct valuations of goods or services from consumers without the use of intermediate variables. Typically the bid game uses a questionnaire format. Respondents are oriented to a hypothetical market (scenario) in which the current level of a good or service is assumed to exist. Then it proposes a change in this level of provision and records the respondents' valuation of that change in the level of provision of the good. Several procedures have been used for obtaining valuations or bids. With an open-ended response format the respondent is unconstrained in providing bids. With a categorical format, the respondent is presented with a predetermined set of bid possibilities. The iterative bid format presents the respondent with a series of alternate states, iteratively eliciting the respondent's valuation of each change from the reference state (Adams, et al., 1980).

The use of prices distinguishes the market from the non-market approaches to valuation (Bradford, 1970). Demand functions for private (marketed) goods quantify demand responses to price changes, and estimation of demand functions is a first step toward benefit estimation. In the case of public goods and publicly provided goods for which production and consumption is often divorced from consideration of individual willingness and ability to pay, consumers do not normally have the opportunity to purchase as many units as they wish. They are, instead, confronted with public decisions to change the quantity or quality levels of provision without joint reference to price. The term "states" is used to refer to current and subsequent levels of provision.

The Bid Curve and Consumer's Surplus

By soliciting valuations in terms of willingness to pay and/or willingness to accept compensation, the bid game method is designed to measure the consumer's surplus. Thus it has the same theoretical basis as value estimating procedures using estimated demand functions for marketed goods and services.

The Bid Curve

Consider an individual who currently enjoys some specified level, Q, of a good or service.[3] He also enjoys a given quantity of the Hicksian "all other goods" numeraire, Y, for convenience called income. His level of utility, then, is a function of his income and the level of provision of the good represented by Q, i.e.,

(1) $U = U(Q, Y)$.

The individual is at the origin (Figure 2), which defines his level of welfare in the "without project" situation. To the right of the origin, the level of provision of Q to the individual increases; to the left of the origin, it decreases. From the origin, a move up the vertical axis represents a decrease in income, while a move down the vertical axis represents an increase in income.

A total value (TV) curve, or bid curve (Bradford, 1970), passes through the individual's initial state. It is of positive slope, given that the individual is not satiated in the range of values under consideration. For decreases in Q, the TV curve lies in the southwest quadrant; for increases in Q, it lies in the northeast quadrant.

The TV curve is an indifference curve, that is,

(2) $U(Q, Y) = U(Q^-, Y^+) = U(Q^+, Y^-)$.

Starting at the origin, $Y^o - Y^-$ is the individual's willingness to pay (WTP) for an increment in the provision of good Q from Q^o to Q^+. Willingess to accept (WTA), i.e., $Y^+ - Y^o$, is the amount of money which would induce the individual to accept voluntarily a decrease in the level of provision of the service from Q^o to Q^-. Restating equation (2),

$$(3)\ U(Q^o, Y^o) = U(Q^-, Y^o + WTA)$$
$$= U(Q^+, Y^o - WTP).$$

WTP, WTA, and Consumer's Surplus

To clarify the relationship between Hicksian compensating and equivalent measures of value, WTA and WTP, and the total value curve of

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[3]The discussion of the bid curve follows that in Brookshire, et al., (1980).

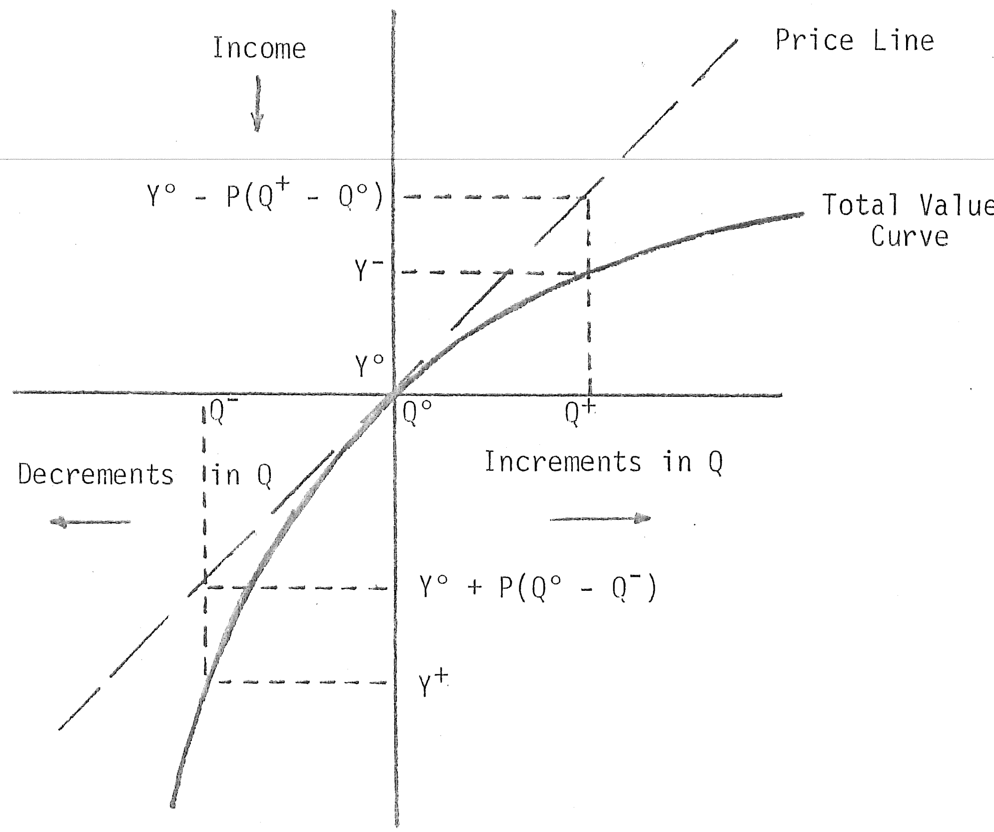

Figure 2.--The total value curve for increments and decrements in the level of provision of a service, Q, for an individual who initially enjoys the level Q° and the income Y°.

Figure 2, Brookshire, et al. (1980) offer the following example. The subject of benefit-cost analysis is a project which would divert a specified area of wildlife habitat to some alternative use, effectively destroying its usefulness as habitat. The analyst needs to know the value of the losses which would be suffered by an individual who currently enjoys the wildlife amenities provided by that habitat. In the initial state the individual has utility level $U(Q^o, Y^o)$. His "with project" utility level will be $U(Q^-, Y^o)$. The "with project" and "without project" levels of Q are predetermined so that the individual has no opportunity for optimizing adjustments.

One measure of the welfare impact on this individual would be his WTA to acquiesce in the proposed change. Call this $WTA^C_{Q^o, Y^o; Q^o, Y^o; Q^-}$.

Superscript C indicates that this is a Hicksian compensating measure of value, the first subscript pair, Q^o, Y^o indicates that the individual's reference level of welfare (his presumed right or entitlement) is Q^o, Y^o. The second subscript pair indicates that Q^o, Y^o is also his initial welfare level. The third subscript, Q^-, indicates the level of provision of the good (in this case, wildlife-related services) the consumer would enjoy after he has accepted the compensation and the change in the level of services. If he were compensated by an amount just equal to his WTA, his income after compensation would be $Y^o + WTA^C$. WTA^C is a measure of the individual's valuation of the reduction in wildlife-related amenities from Q^o to Q^- and was derived from the individual's TV curve for wildlife-related amenities (see Figure 3).

However, another measure of value might have been used to estimate the individual's loss of wildlife-amenities: the amount of money he would be willing to pay to avoid a reduction in the provision of wildlife amenities. This WTP to avoid a less preferred position reflects a presumption that the individual has no right (entitlement) to his current welfare level. The reference level of welfare is not that associated with the initial situation, but the proposed (or subsequent) welfare level. This second measure of the individual's welfare loss is denoted $WTP^E_{Q^-, Y^o; Q^o, Y^o; Q^o}$. The superscript E indicates a Hicksian equivalent measure of value. The first subscript pair indicates that the reference level of welfare (his entitlement) is taken to be Q^-, Y^o. The second subscript pair indicates the individual's initial state, Q^o, Y^o. The third subscript indicates that the individual, after he has paid will be allowed to enjoy the Q^o level of amenities. If he pays WTP^E, his final income will be $Y^o - WTP^E$.

Brookshire, et al. (1980) note that the pair of total value curves in Figure 3 could be used to estimate the value of a project which would increase the level of wildlife-related amenities from an initial level Q^- to a "with project" level Q^o. The individual's initial state is Q^-, Y^o. If the individual is entitled only to his initial welfare level, the appropriate measure is $WTP^C_{Q^-, Y^o; Q^-, Y^o; Q^o}$. Note that WTP^C equals WTP^E. If the individual were entitled to the additional wildlife-related amenity, the measure is $WTA^E_{Q^o, Y^o; Q^-, Y^o, Q^-}$ which equals $WTA^C_{Q^o, Y^o; Q^o, Y^o, Q^-}$.

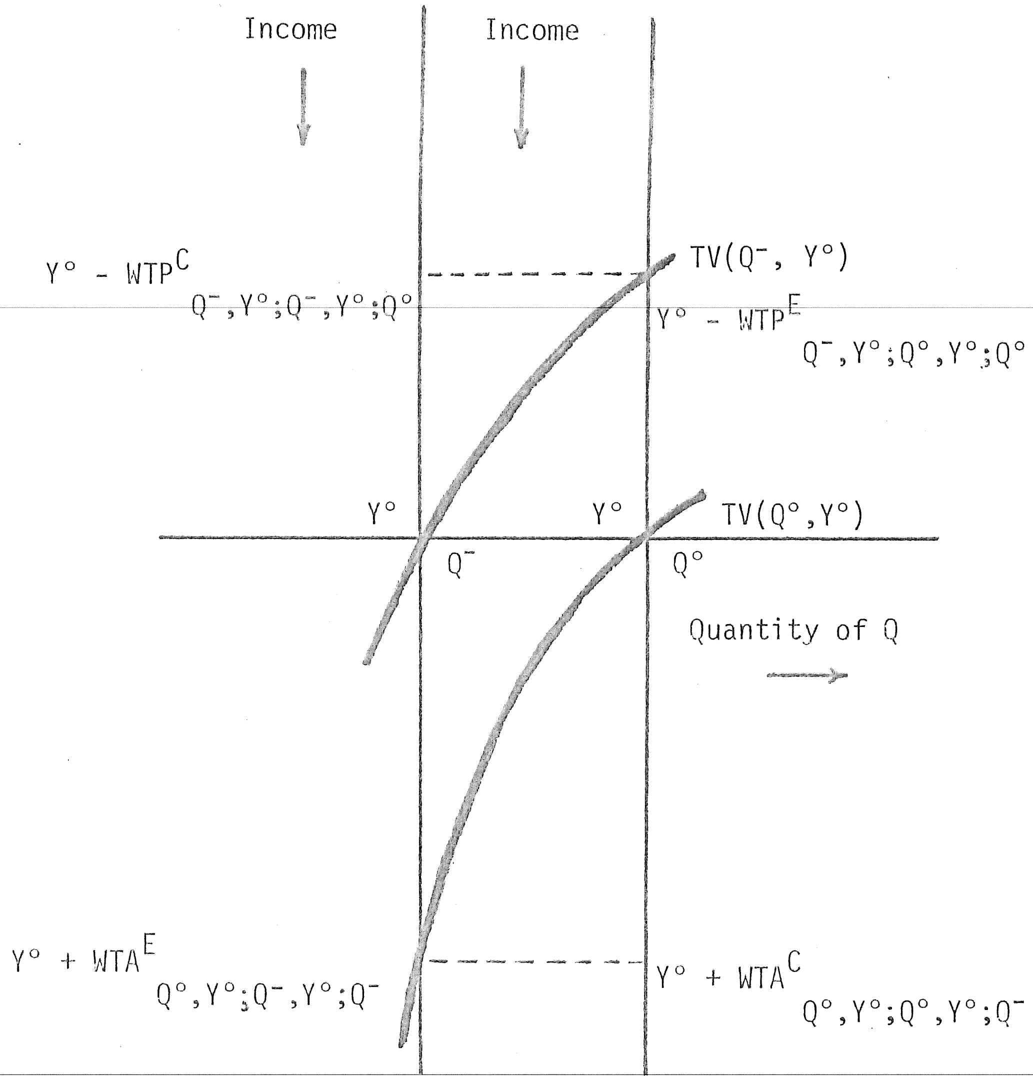

Figure 3.--The relationships between WTP and WTA, and Hicksian compensating and equivalent measures of consumer's surplus.

The example makes several points.

(1) Equivalent measures apply to situations in which the initial welfare level is different from the reference level, when the individual's "entitlement" is given by the subsequent state rather than by the initial state.

(2) Compensating measures assume that the initial state is the reference welfare level; that the individual's "entitlement" corresponds to the initial state.

(3) WTP^E cannot be found using a TV curve passing through the individual's initial state. It can be found only by using another TV curve passing through the reference state.

(4) There is a compensating and equivalent version of WTP, as there is of WTA. When comparing two alternate levels of provision of a good, there are four relevant Hicksian value measures: WTP^C to obtain the preferred level; WTP^E to avoid the less preferred level; WTA^C to accept the less preferred level; and WTA^E to forego a promised increment to the preferred level.

(5) WTA and WTP, whether they be compensating or equivalent measures, represent Hicksian variations if the consumer has an opportunity to make optimizing readjustments in his consumption set.

(6) WTA and WTP, whether they be compensating or equivalent measures, represent Hicksian surpluses if no optimizing adjustments in the individual's consumption set are possible.

Application of the Iterative Bid

Application of the iterative bidding technique [also known as "contingent market valuation (Randall and Brookshire, 1978)] requires identification of the distribution of rights. That is, the quantity of a good to which a respondent is entitled must be determined before the relevant consumer's surplus measure can be chosen. For example, if the consumer is entitled to the quantity he currently consumes and a proposed project would reduce the quantity available to him, the relevant consumer's surplus measure would be WTA^C. On the other hand, if the consumer is entitled only to the reduced quantity the relevant measure would be WTP^E.

The contingent market or iterative bid format requires that the respondent understand the quantity and quality characteristics of the scenario with which he is confronted. For example, in a study of willingness to pay for environmental improvements, Randall and Brookshire (1978) used photographs to depict levels of provision of cleaner air to ensure uniform perception among the respondent population.

The payment method or vehicle must be chosen for its relevance and feasibility and must be clearly specified to the respondents (Randall and

Brookshire, 1978). For example, expressions of willingness to pay for increased recreational opportunities or wildlife-related amenities might best be elicited in terms of willingness to pay hunting license fees or recreational site access fees, since these vehicles of payment are familiar to consumers and relevant to the specific goods or amentities for which measures of valuation are sought.

In the iterative bidding form of contingent market valuation the respondent reacts to prices posed by an enumerator, indicating whether he would (in a WTP case) pay the price or go without the good. The price is varied iteratively until the price at which the respondent is indifferent is identified (Randall and Brookshire, 1978). The hypothetical market thus established has the advantage of low transactions costs, "trade" in goods which cannot be marketed in the conventional sense, the ability to evaluate many options and perturb the components of publicly provided packages of goods (and packages of public goods) in order to examine the contributions of these components to the value of the package. Contingent market approaches to valuation are inferior to actual markets in that the bids obtained are not firm, enforceable offers, but are behavioral intentions given the occurrence of the hypothesized contingencies. If the survey instrument is realistic and coherent, then the main conditions under which behavioral intentions should predict actual behavior can be met. Studies by Ajzen and Fishbein (1977) and Crespi (1971) have been used as the psychological foundation for the economic research in hypothetical valuations.

Potential Bias in Iterative Bids

Empirical application of the iterative bid poses three problems:

(1) the potential exists for respondents to engage in strategic behavior;

(2) variations in responses may result from using different starting points for the same bid; and

(3) variations in response may result from the use of different vehicles of payment for the same bid.

Strategic Behavior Bias

Of the three possible sources of bias, respondent strategic behavior is of the most concern and has consequently precipitated the most research. The problem of strategic behavior arises from the very essence of the contingent market valuation method: its hypothetical nature.

It is necessary to distinguish strategic behavior which may result from paucity of information concerning procedures and purposes of the survey, or from a marked divergence between the survey scenario and experiences of real life. In other words bias can be introduced into participant responses simply from confusion.

Strategic behavior results when the respondents in an attempt to maximize personal self-interests, sabotage the bid game by responding dishonestly to the questions. It has been generally accepted that respondents attempting to maximize the benefits which may possible accrue from a survey encounter will answer questions in a predictable manner. The two main factors which affect the response are (Freeman, 1979):

(1) the individual's perceived personal influence on the outcome, and

(2) the probability that he will actually have to forfeit the amount he states as his maximum willingness to pay (when WPA is the desired measure).

The tendency for an overstatement of one's true willingness to pay occurs when the individual desires a certain outcome and believes that his responses will affect that outcome but that he will not be asked to actually relinguish that bid amount. An understatement will occur when a respondent desires an outcome but believes that the number of participants is large enough to ensure that outcome regardless of the size of his bid which he may, in fact, be required to relinguish. These two biases are considered to be the upper and the lower bounds on bid estimates and are the key targets for solutions to systematic bids in surveys (Bohm, 1972).

Researchers have attempted to adjust for the effects of strategic responses in two ways. The first approach attempts to measure, statistically, the bias imposed by strategic responses and adjust recorded responses by this calculated degree of bias (Kurz, 1974). This procedure is based on the unverified assumption that all biases in a given situation are uniform, and suffers from lack of operational format to follow from its theoretical exposition.

The second approach to potential strategic behavior attempts to structure questions in the survey situation to eliminate incentives for strategic behavior (Bohm, 1971). Respondents are left uncertain as to how their responses will affect their payment outcome. This can be achieved by informing them that they may be called upon to pay their bid, some proportion of their bid, or to make no payment at all. This uncertainty will create no clear advantage to the respondent in understating or overstating his true bid. This approach of "outwitting" the respondent has been explored theoretically by Mäler (1974), Kurz (1974), and Tideman and Tullock (1976). It is the approach used in the attempts at non-market valuation represented by the work of Adams, et. al. (1980), Cicchetti and Smith (1973), Randall, et. al. (1974), and Hammack and Brown (1974).

Elimination of incentives for strategic responses may also eliminate incentives for giving accurate answers (Freeman, 1979). Care must be taken to stress the importance of careful and thoughtful answers (Hammack and Brown, 1974). It is also probable that respondents will, in any case, attach a probability of their own choosing to the potential influence of the survey and of their bids (Freeman, 1979). These problems are embodied in what Randall and Brookshire (1978) calls conflict between "strategic versus hypothetical bias," the latter being the result

> ...not of systematic influences but rather of noise resulting from failure to invest as much effort in the contingent decision as would be invested in an actual decision, presumably because the penalties from a wrong decision in a hypothetical market are not so tangible (Randall and Brookshire, 1978).

This discussion reemphasizes the need to distinguish between genuine strategic behavior and the bias caused by lack of relevance, and accentuates the need for conveyance of reality in the design of contingent market scenarios.

Although no methodology exists which conclusively tests for strategic bias, two empirical studies made by Bohm (1972) and Brookshire, et al., (1976) have attempted to reveal its existence. Bohm's study consisted of five separate surveys, each intended to elicit a certain biased response in situations which were not hypothetical (respondents had to actually pay their total bid or some proportion. The main result of the test was that none of the five surveys yielded average bids which significantly deviated from any of the others. Results of surveys which were designed to elicit overstated bids did not differ greatly from those which intended to elicit understated bids (based on criteria mentioned above). The difference came with the sixth survey which was based on a situation known to the respondents as "hypothetical." Bohm concluded that, in any case, the behavior exhibited supports the notion that respondents tend to view their impact on total demand as important and that understatements are neutralized by the potential threat that a good may not be provided. Bohm makes it clear that this limited testing does not disprove the possibility of bias but suggests that the deviation between honest and biased response may be small.

The study by Brookshire, et al. (1976), which measured the value of improvements in air quality of an Arizona recreation and wilderness area, confronted survey respondents with a hypothetical situation in which the respondents knew the survey personnel were not working in an official capacity and that they would not be required to actually provide for payment or receive compensation. The authors hypothesized that bias, if it existed, would be exhibited in the following way: when asked what their maximum willingness to pay would be to insure an improvement in environmental quality, the "environmentalists" would tend to overstate their bids, far exceeding the mean, and "non environmentalists" bids would tend to be zero. The authors assumed that honest bids would be distributed normally, and that bias of the hypothesized type, if widespread, would tend to flatten the distribution. They concluded that strategic bias was not prevalent in their survey because the distribution was, in fact, highly centered about the mean bid. However, they recognized that strategic bias may still exist since they have no way of insuring that bids were influenced by an incentive to be accurate.

In summation, strategic behavior in hypothetical bidding cannot be completely eliminated because it cannot be accurately measured. At best, its vestiges, arising in either an actual or hypothetical situation, can only be hypothetisized. That the problem exists, however, is generally agreed upon. The ultimate caveat is that the confidence associated with the statistical testing of bid estimates does not indicate the reliability with which behavioral intentions will be translated into actual behavior.

Vehicle of Payment Bias

Vehicle of payment bias can be said to exist when the value of mean bids or the incidence of protest bids are significantly different across payment vehicles (Randall and Brookshire, 1978). In such cases it is possible that respondents are revealing a preference for paying a bid in one form rather than another and disguising a true willingness to pay.

Two studies have specifically addressed the potential for vehicle of payment bias in their work. Randall et. al. (1974) did not find vehicle bias at statistically significant levels in their research, but at less stringent levels of significance some differences were observed between the sales tax, the user fee, and the electricity bill forms of payment. The authors suggested that the vehicle of payment selected for any respondent group should be the most germane to the issue at hand. This appears to make the most intuitive sense. Individuals confronted with forms of payment which they do not prefer may tend to give low bids, and, while it may seem less likely, persons confronted with the payment form "of their choice" may tend to give higher bids. The most likely-to-be-employed form of payment would assist in smoothing the extremes.

Starting Point Bias

Starting point bias exists if different bids are elicited from a set of questions which contain, ceterus paribus, different starting points. If a starting point bias exists, a bid game with iterations beginning at \$2.00, rather than at \$1.00, would produce bids which are biased upward. Randall and Brookshire (1978) suggest that starting point bias is only a problem for situations in which respondents have little independent basis for valuation of the good. As with vehicle of payment bias, starting point bias may be tested for by varying the starting point across the sample and testing whether the responses differ significantly between groups.

CHAPTER IV

VALUING RESIDENTIAL WATER USE BY CONTINGENT MARKET TECHNIQUES

WTP, WTA, and Consumer's Surplus for Residential Water Use

The relationship between Hicksian compensating and equivalent measures of value and WTA and WTP in the context of residential water is illustrated by the following scenario. Hypothetically, if current trends in population growth continue, demand for water will exceed existing capacity for supply in five years.[4] A project to augment water supply capacity will make it possible for current rates of use per household (Q, in Figure 4) to be sustained in five years. Failure to invest in increased supply capacity will require an average decrement in Q relative to current rates of consumption.

If it is assumed that citizens are entitled to their existing level of utility, the benefit-cost analyst wishes to measure consumer's WTA^c (Willingness to Accept payment) for voluntarily accepting decrements in water availability and, therefore, water use. This measure is a compensating measure, denoted by superscript c, since it assumes individuals are entitled to current utility levels.

Figure 4 depicts the situation just described. The consumer starts at Y°, Q°, and is entitled to the level of utility associated with that situation. If a decrement from Q° to Q^- is inevitable, the question to the consumer becomes, "What amount of compensation will you accept to voluntarily acquiesce in the decrement in Q and feel as well off as before the decrement in Q? In Figure 4 the WTA^c is depicted at $Y^\circ + WTA^c$.

On the other hand, if a decrement from Q° to Q^- is inevitable and the consumer is not entitled to his existing level of utility, the appropriate question to ask the consumer is, "How much are you willing to pay to avoid a decrement in water availability from Q° to Q^-?" In this case, the level of welfare (reference level) to which the individual is entitled is that associated with Y°, Q^- in Figure 4. The WTP^E (Willingness to Pay) to avoid the decrement in Q represents a decrement in income relative to the initial Y° level, leaving the consumer at income level $Y - WTP^E$. Moreover, the contingency as proposed entails a loss of welfare for the individual, a new reference level of Y and Q, and a different TV curve.[5] The superscript, E, denotes an equivalent measure.

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[4]The time reference to five years is selected arbitrarily for purposes of illustration.

[5]An additional point can be raised concerning interpretation of the above scenario. The scenario posits "inevitable" reductions in Q (unless supply capacity is augmented), and for urban water systems customers, it is not clear whether individual customers would (or could) make subsequent quantity adjustments. If it is assumed, for example, that customers can

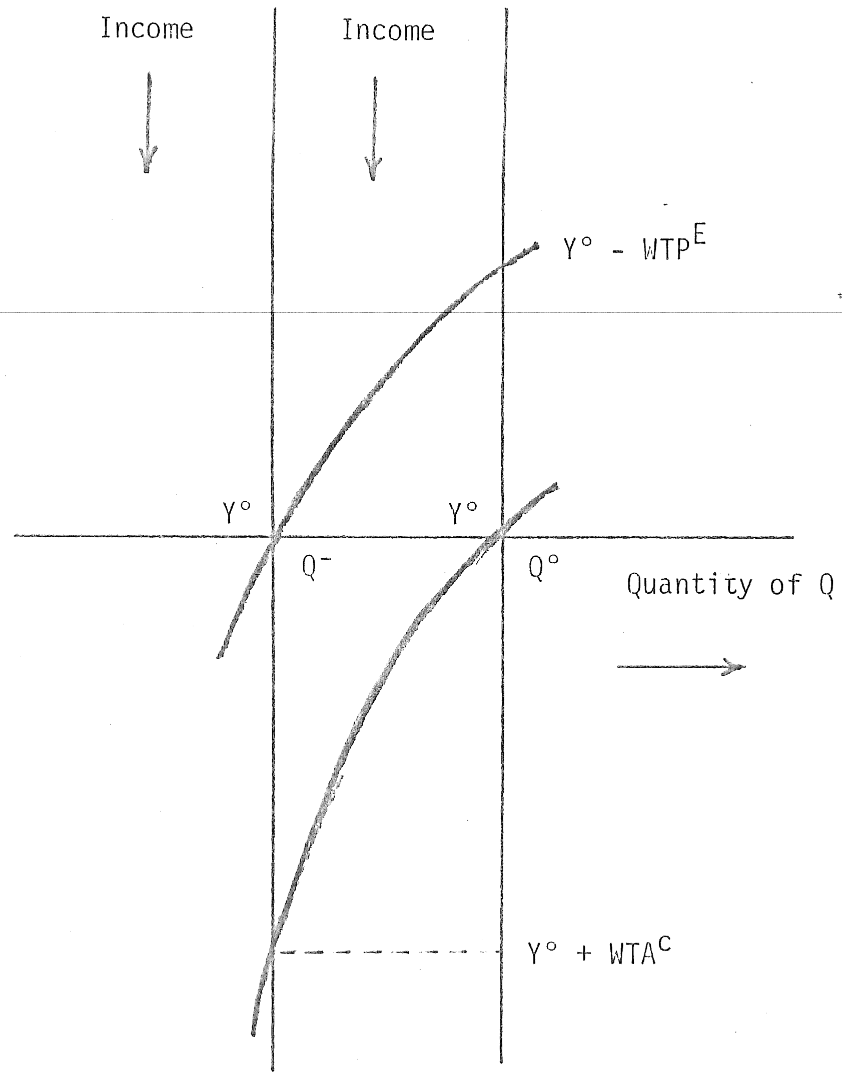

Figure 4.--Relationship of WTP, WTA and Hicksian measures of surplus: the context of residential water use.

Exposition Using Traditional Indifference Curves

Figure 4 depicts the relationship of WTP^E and WTA^C to Hicksian equivalent and compensating surpluses in terms of the total value (bid) curve for residential water. Figure 5 allows diagrammatic exposition in terms of traditional indifference curves [following the exposition by Randall and Stoll (1980)].

Consider an individual whose rate of use of residential water, Q, and an "all other goods" numeraire represented by income, Y, is currently Q° and Y°, respectively (corresponding to the origin of Figure 4) and permitting the individual to achieve utility level I° at point C. Now, assume that Q must be reduced to Q^- from Q°, but the individual is entitled to remain at his original utility level. If no income compensation were received by the individual, he would find himself with income Y° (unchanged) and quantity Q^- (reduced from Q°) permitting him to achieve only utility level I' at point B.

Since the scenario depicts a quantity change without reference to rate or price changes, price lines are irrelevant to this indifference curve analysis.[6] Compensation needed to return this individual to his original utility level will be BA which equals $Y^\circ Y'$, and which corresponds to WTA^C in Figure 4. In Hicksian terms, this WTA^C is a compensating surplus.

Alternatively, consider an individual with income Y° and quantity of water Q who is at point C on utility level I°. Assume further that the level of Q must be reduced from Q° to Q^- and that the individual is not entitled to compensation. The individual's willingness to pay to continue using Q° of water is WTP^E and will be the amount of Y he would have to give up in order to reach point D, on utility level I', corresponding to quantity Q°. This WTP^E is, in Hicksian terms, an equivalent surplus and amounts to CD in Figure 5, equaling $Y''Y^\circ$. On Figure 4, this corresponds to WTP^E. This arrangement leaves the individual on a different lower indifference curve, I' at point D.

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not resell publicly supplied water in a competitive market, the relevant compensating and equivalent measures are Hicksian surpluses, rather than variations. On the other hand, if it is assumed that competitive markets for the re-sale of publicly supplied water would emerge in the wake of mandatory supply reductions (or use reductions), then the compensating and equivalent measures are Hicksian variations, not surpluses.

[6]The irrelevance of price lines also hinges on the assumption that no "after market" for the private exchange of publicly supplied water exists.

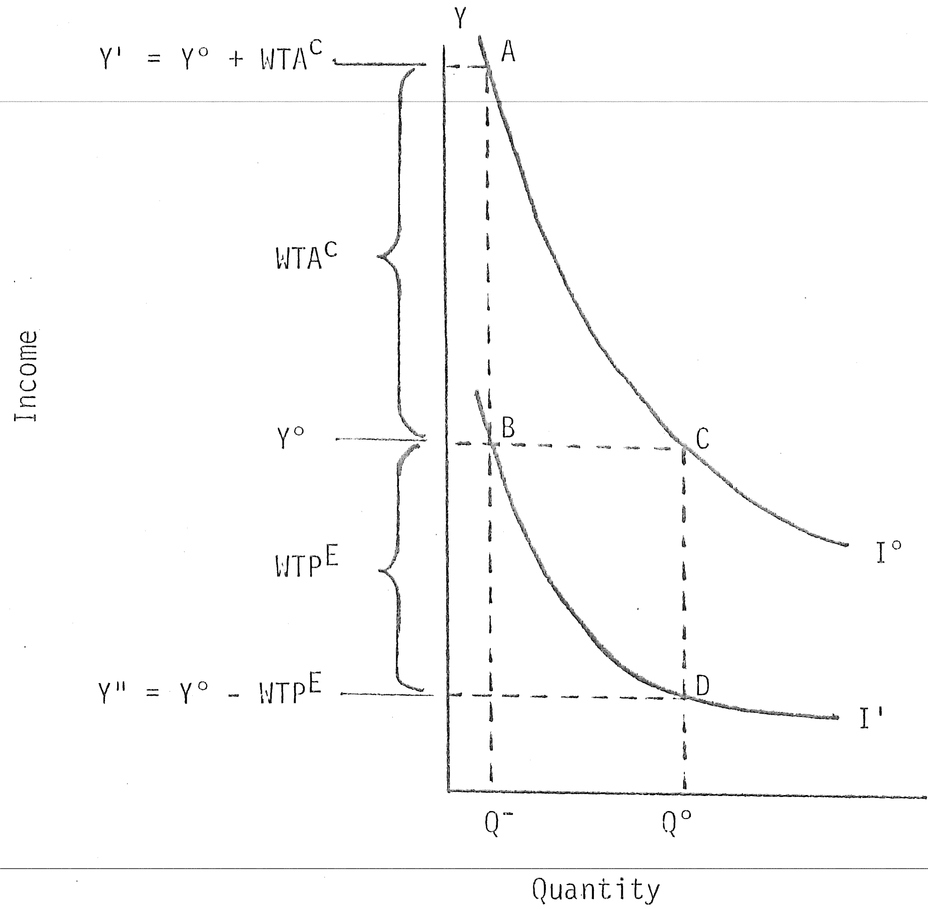

Figure 5.--Diagramatic exposition, using traditional indifference curves, of the relationship of WTP, WTA, and Hicksian measures of consumer surplus; the context of residential water use.

Valuation of Residential Water Use

Introduction

This study pursued three objectives:

(1) to measure consumers' valuations of the losses in utility which correspond to reductions of water in specified residential uses,

(2) to identify the major determinants of these individual valuations, and

(3) to quantify the relationship between those determinants and the individual valuations.

The method employed to measure consumers' valuations was the contingent market, using the iterative bid. Selection of independent variables was based on the hypothesis that variables which affect a household's monthly water demand will be similarly correlated to the individual consumers' valuations. Multiple regression analysis was used to test for, and to quantify, significant functional relationships between the selected independent variables and the consumers' valuations.

The Dependent Variables

WTP and WTA were solicited by personal interviews with a sample of residential water users and are direct measures of the consumer's surplus derived from residential water use. The individual bids were used to compute the mean bids for the sample.

WTP and WTA bids were obtained for each of five categories of residential water use:

(1) toilet flushing,

(2) bathing and showering,

(3) clothes washing,

(4) lawn watering, and

(5) total household water use.[7]

The contingent market scenarios

Each respondent was visited personally by a survey enumerator and asked to respond to a hypothetical situation concerning the eminent

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[7]Of these five categories, the bid functions for clothes washing and lawn watering were not estimated because the data base contained too many missing values in the corresponding bid and quantity figures.

availability of water for selected household activities. Specifically they were told:

> Please indicate your willingness to pay, through charges in your monthly water/sewer bill, for water in specific uses. Imagine that requirements are set for water use reductions but that you may avoid compliance if you are willing to pay to do so.

Respondents were then allowed, through an iterative procedure, to select a monetary bid representing their willingness to pay, for example, to avoid a 20% reduction, a 30% reduction, and a 40% reduction, respectively, in each of the five categories of household water use.[8] To elicit bids for each reduction contingency, the respondents were asked the following:

> If there was a requirement to reduce bath/shower usage in your household by 20%, how much additional money would you be willing to pay per month to avoid complying with this requirement?

Iterations of bids were then presented to the respondents, beginning with the current price they pay for the amount of water represented by the reduction contingency. The completion of this process produced a set of WTP bids.

The WTA bids were elicited in a similar manner, essentially using the following scenario:

> If you had decided to comply with the requirements of water use reduction what amounts of compensation would you require to repay you for the inconveniences which you incur when you make these reductions? Please indicate the minimum amount of money which you could accept through reductions in your monthly bill, for specific water uses.

Dealing with sources of bias

It was crucial to the design of the iterative bid section of the questionnaire that the problems of bias (see Chapter III) not be built into the data. Although strategic bias, starting point bias, and vehicle of payment bias cannot be conclusively identified or eliminated, efforts were made to minimize their occurrence.

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[8]The entire questionnaire has been included as Appendix I. Reduction contingencies were expressed in different terms for different uses, eg., in terms of hours per week for lawn watering, flushes per day for toilet flushing, cycles per week for clothes washing, etc.

To counteract the potential for strategic bias, the bid scenario was characterized as being hypothetical (it was emphasized that the enumerators were not acting in any official capacity). On the other hand, enough "reality" may well have been injected into the scenario by the fact, well known to the consumers, that recent water price increases had been effected in both cities from which samples were drawn.[9] It was hoped that in consequence of these two factors respondents would see no personal benefit to sabotaging a hypothetical bid game but would recognize the general pertinance of the scenario.

To minimize the likelihood of starting point bias, current water rates were used as the basis for the opening bid for all questions. Respondents were therefore not confronted with unrealistically high or low initial bids.

Care was taken to minimize vehicle of payment bias by using the most realistic form of payment: the water bill. Since no other form of payment is relevant there was no need to include other payment vehicles to test for significant discrepancies.

The personal interview method was used to minimize the likelihood of bias resulting from misunderstanding of the purpose or procedure of the questionnaire.

The Independent Variables

The variables which affect a household's monthly water consumption are hypothesized to also affect that household's valuation of water use. The logic behind this hypothesis is relatively simple: the WTA and WTP bids are measurements of value, or more accurately, expressions of individual perceptions of value. This value is derived from the utility of household water which, in turn, is a function of how water is used and how much water is used.

How water is used and how much is used by a household are items of information which the independent variables were designed to reflect. Some variables were expected to have positive influences on valuation and others were expected to have negative influences.

The variables were categorized in the following variable groups:

(1) the household status group

(a) number of members per household

(b) annual income

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[9]The sampling procedure and characteristics of the cities from which samples were drawn is included as Appendix II.

(2) the household technology group

(a) average total monthly water consumption

(b) average monthly water consumption for each water use category

(c) the presence of a private well

(d) type of irrigation system

(3) the conservation group

(a) belief in local water shortage

(b) expressed willingness to decrease water consumption if the price were increased by 50%.

The rationale for selecting each variable and the hypothesized nature of its relationship to individual bids, varies from one variable to another.

The household status group

Size of household. The number of persons in a household is hypothesized to have a positive influence on the willingness to pay to maintain current levels of water use. As the number of persons in a household increases the necessary minimum rate of water use also increases. Size of household is also expected to have a positive influence on the willingness to accept compensation for essentially the same reason.

Annual income. Income is hypothesized to have a positive influence on the willingness to pay an increased amount to maintain current water use levels. Willingness to pay is expected to be related to ability to pay. It may also be positively correlated with the willingness to accept compensation for water use reductions.

The household technology group

Monthly average water consumption. The monthly average quantity of water that a household uses is hypothesized to be positively correlated with both the willingness to pay and the willingness to accept bids It is expected that households which require relatively large quantities of water are those which rely upon numerous water using appliances, e.g., more than one bath room, and/or have larger family sizes.

Monthly average consumption for each water use category. The presence and use of specific household water using fixtures is an indication of how much water the household is likely to feel it "needs." It is hypothesized that the average rate of each water use will be positively correlated with willingness to pay to avoid, and willingness to accept payment to acquiesce in, reductions in those particular use rates.

Presence of private well. The presence of a well is hypothesized to have a negative effect on willingness to pay to maintain current levels of water use because the well is a substitute for publicly supplied water. If the well water is used for irrigation only it is not a perfect substitute since it is often not of potable quality and because there are normally official restrictions on the use of wells. Consequently, the effect of a private well on WTP and WTA will be less if the well is used only for irrigation.

Type of irrigation system. Irrigation systems which use the most water should have the greatest positive effect on willingness to pay to maintain current levels. The automatic sprinkler system requires more water to operate efficiently than does a rotating hose-and-sprinkler system. Therefore, the presence of the former should be more highly correlated with WTP and WTA than the latter.

The conservation variable group

Belief in water shortage. The belief in a current or pending water shortage is hypothesized to have a positive effect on the willingness to pay to maintain current levels of water use. Recognition of scarcity implies recognition of the likely increase in cost of maintaining a particular rate of supply to households.

However, recognition of water shortage situation may have the opposite effect on WTA. Recognition of a true shortage may entail a willingness to acquiesce in measures to curtail use without demanding or expecting compensation.

Willingness to reduce consumption in the event of an increase in price of water. This variable measures a willingness to conserve water, reflecting an attitude about the need or desirability of conservation. It is hypothesized that a greater willingness to reduce consumption is positively correlated with a willingness to pay to avoid reduction in use and negatively correlated with WTA.

Estimating Equations

Willingness to Pay

The estimating equations to explain willingness to pay to avoid reductions in total water use are:

(1) WPWAT10 = f(NUMRESPH, INCOME, AVGCON10, HAVEWELL, KINDSYS, BELWSHRT, DECON50),

(2) WPWAT30 = f(NUMRESPH, INCOME, AVGCON30, HAVEWELL, KINDSYS, BELWSHRT, DECON50),

(3) WTWAT50 = f(NUMRESPH, INCOME, AVGCON50, HAVEWELL, KINDSYS, BELWSHRT, DECON50),

where:

WPWAT10, WPWAT30, WPWAT50 = amount of increase in the total monthly water bill that a consumer is willing to pay to avoid 10%, 30%, and 50% reductions, respectively, in monthly average water consumption,

NUMRESPH = number of persons residing in household,

INCOME = combined annual income of persons residing in household,

AVGCON 10, 30, 50 = figure representing a negative 10%, 30%, 50% respectively of monthly average water consumption,

HAVEWELL = indication of whether or not household owns a private well and whether or not it is used solely for lawn irrigation,

KINDSYS = indication of whether or not household waters a lawn and what method, hose and sprinkler, or automatic system, is applied,

BELWSHRT = indication of whether or not household believes that there is a current water shortage in its locale and/or that there will be a shortage by the year 2000,

DECON50 = indication of whether or not household would be willing to reduce its household water consumption if the price of its water rose by 50%.

The estimating equations to explain willingness to pay to avoid reductions in bath and shower use are:

(4) WPBS20 = f(NUMRESPH, INCOME, BATHSQ20, BELWSHRT, DECON50),

(5) WPBS30 = f(NUMRESPH, INCOME, BATHSQ30, BELWSHRT, DECON50),

(6) WPBS40 = f(NUMRESPH, INCOME, BATHSQ40, BELWSHRT, DECON50),

where:

WPBS20, WPBS30, WPBS40 = willingness to pay per month to avoid 20%, 30%, and 40%, reductions, respectively, of monthly average water use in household, for bathing and showering.

BATHSQ20, BATHSQ30, BATHSQ40 = a negative 20%, 30%, and 40%, respectively, of monthly average water use in household, for bathing and showering.

All other variables retain the same definitions as for equations (1), (2), and (3).

The estimating equations for the willingness to pay to avoid reductions in toilet flushing water use are:

(7) WPTF1 = f(NUMRESPH, INCOME, TOILQ1, BELWSHRT, DECON50),

(8) WPTF2 = f(NUMRESPH, INCOME, TOILQ2, BELWSHRT, DECON50),

(9) WPTF3 = f(NUMRESPH, INCOME, TOILQ3, BELWSHRT, DECON50),

where:

WPTF1, WTPF2, WPTF3 = monthly willingness to pay to avoid reducing toilet flushing by an average of 1 time, 2 times, 3 times per person per day.

TOILQ1, TOILQ2, TOILQ3 = figure representing a negative monthly quantity of water corresponding to 1, 2, and 3 flushes of the toilet per person per day.

All other variables retain the same definitions as in equations (1), (2), and (3).

Willingness to Accept

The estimating equations to explain willingness to accept (WTA) compensation to voluntarily accept specific reductions in total household water use are:

(10) WAWAT = f(NUMRESPH, INCOME, HAVEWELL, KINSYS, BELWSHRT, DECON50, AVGCONT),

where:

WAWAT = willingness of the consumer to accept compensation in the form of a reduced monthly water bill to acquiesce in a specified reduction in monthly total household water use,

AVGCONT = the quantity reduction (carrying a negative sign) in monthly total water use to which the consumer's WTA pertains.

All other variables are as defined for equations (1), (2), and (3).

The estimating equation to explain WTA compensation to voluntarily accept a specified reduction in water used for bathing/showering is:

(11) WABS = f(NUMRESPH, INCOME, BELWSHRT, DECON50, BATHST),

where:

WABS = willingness to accept compensation in the form of a reduced monthly water bill, for a reduction in water used for bathing/showering,

BATHST = the quantity reduction (carrying a negative sign) in monthly water use for bathing and showering to where the consumer's WTA pertains.

All other variables are defined as in equations (1), (2), and (3).

The estimating equation to explain WTA compensation for reductions in water used for toilet flushing is:

(12) WATF = f(NUMRESPH, INCOME, BELWSHRT, DECON50, TOILT),

where:

WATF = willingness of the consumer to accept compensation, in the form of a reduced monthly water bill, for a specified reduction in water used for toilet flushing,

TOILT = the quantity reduction (carrying a negative sign) in monthly water used for toilet flushing to which the consumer's WTA pertains.

All other variables are as defined in equations (1), (2), and (3).

The Estimation Procedure

The estimating equations for WTP and WTA postulate causal relationships between the observed bids and each of several independent variables. The procedure for estimating the parameters of those equations and testing for statistical significance of the coefficients is multiple regression analysis. A complete exposition of this procedure can be found in any standard econometrics text book [for example, Wonnacott and Wonnacott (1970)].

The Questionnaire

Information on the hypothetical variables was obtained using primary and secondary data collection methods. The WTP and WTA bids, and all data excluding monthly water consumption data were collected through a questionnaire. Customer records of the water utilities of the two cities from which samples were drawn, St. Petersburg and Orlando, were used to obtain the water consumption data for the period November 1978 - October 1980.[10]

The questionnaire was personnally presented by trained enumerators. It was suspected that the complexity of the questionnaire would have created data problems if respondents were left solely to their own interpretations of the questions.

It was anticipated that bids would differ between geographic areas which experience, either currently or in the recent past, different water availability conditions. To test this hypothesis two sampling groups were chosen, St. Petersburg and Orlando. The former has a history of water scarcity problems and the latter is located in a relatively water plentiful area of the state. (See Appendix II for a complete discussion of the sampling procedure).

The questionnaire (Appendix I) contained four sections designed to provide data on:

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[10] St. Petersburg Public Utilities in St. Petersburg and the Orlando Utilities Commission in Orlando.

(1) the socioeconomic status of the household: income, household size, education, etc.;

(2) the estimated amount of use of water using facilities and appliances in the consumer's home;

(3) the actual valuation of water in specific activities (the WTP, WTA bids)

(4) the beliefs and attitudes the consumer had concerning water scarcity in his/her region, and concerning water conservation practices.

The third section of the questionnaire, discussed in a previous section, provided the WTP and WTA bids.

CHAPTER V

RESULTS OF ANALYSIS

Four aspects of this research are of interest:

(1) the success of the questionnaire and the survey procedure in terms of usable responses,

(2) the difference between WTP and WTA bids for the same sample in the same water use category,

(3) the difference between corresponding mean bids for the St. Petersburg sample and the Orlando sample,

(4) the results of the regression analysis.

These aspects will be discussed in turn in the following sections.

Response to the Questionnaire

For St. Petersburg, 182 households were contacted and 165 questionnaires were completed. Of these, 114 were usable. Therefore, 63% of the 182 household contacts produced usable questionnaires.

For Orlando, 130 households were contacted and 120 questionnaires were completed. Of these, 62 were usable. Therefore, 48% of the 130 household contacts produced usable questionnaires.

The surveys rejected represented protest bidders. Protest bidding is demonstrated through respondents' answers which reveal a failure to properly play the bidding game. Where answers indicated that a respondent did not consider the tradeoff process between paying (receiving) money and acquiring (foregoing) water in a specific use when making a bid, the bids were rejected. This generally took the form of zero bids with explanations of their unwillingness to pay money or accept compensation.

The following criteria were employed to determine protest bids:

(1) bidding all zeros: persons registering zeros for all thirty WTP and WTA questions were considered unwilling to play the bid game because it is highly unlikely that "true" responses would be such. For St. Petersburg this eliminated 12 surveys, or 7% of the original sample; in Orlando this eliminated 32 surveys, or 25% (see Table 1);

(2) bidding lowest amounts for WTP and highest amounts for WTA: again it is unlikely that bids this consistent are "true." Also it is blatantly contradictory to register the highest value for WTA and the lowest value for WTP in the same use category. This criteria eliminated 1 survey in St. Petersburg and 7 surveys in Orlando.

Table 1.--Criteria for rejecting surveys

Criteria	Number (%) of surveys unuseable			
	St. Petersburg - 182		Orlando - 130	
Bidding all zeros	12	(7.0)	32	(25.0)
No consumption data	19	(10.0)	28	(22.0)
Zero bid for WTP, highest bid for WTA	1	(0.5)	7	(5.0)
Not willing to reduce or pay more	8	(4.4)	-	
Would pay anything	1	(0.5)	-	
Across the board compliance	3	(2.0)	-	
Minimum users	6	(3.0)	-	
Critical inconsistencies	1	(0.5)	1	(0.8)
Not returned	17	(9.0)	-	
Total used	114	(63.0)	62	(48.0)
Number of WTA only	9	(5.0)	14	(11.0)
WTP only	1	(0.5)	1	(0.8)
Number with both games	104	(57.0)	47	(36.0)
Number of bids:				
WTP equations	1,092		655	
WTA equations	1,150		777	

(3) indicating an unwillingness to pay or reduce usage: persons so bidding were not open to the tradeoff design of the bid game. Their zero bids failed to consider the available choices. This eliminated 8 surveys in St. Petersburg and none in Orlando.

(4) indicating a willingness to pay anything: again, the person is not considering the tradeoff. Also, it is not realistic for a person to be willing to pay "anything" since willingness is a function of capability to pay. This eliminated 1 survey in St. Petersburg and none in Orlando.

(5) indicating total compliance: persons who indicated across the board compliance with water use reductions were rejected because it is unrealistic to assume that the major reductions (e.g., 50% of all water use) could be enacted in lieu of even the lowest price. This eliminated 3 surveys in St. Petersburg and none in Orlando.

(6) indicating minimum usage: persons who felt that their current level of water consumption was at its minimum were not willing to consider reductions for any price. This eliminated 6 surveys in St. Petersburg and none in Orlando.

(7) critical inconsistencies: as will be explained below, some bids were inconsistent and accepted in particular cases, however, when all bids appeared to be consistently inconsistent with no apparent justification, the entire survey was eliminated. This eliminated 1 survey from each city.

Two other reasons for eliminating surveys existed which were unrelated to protest bidding. First, 17 surveys were not completed and returned from the St. Petersburg enumerators. Second, water use consumption data was unavailable for a percentage of each sample. In St. Petersburg 12 surveys were from respondents who were not listed as customers of the St. Petersburg Public Utilities Company. In Orlando where utility data collection was not possible because customers' names were not provided, respondents estimates of water use had to be utilized. For 28 surveys this estimate was not provided. Thus, for St. Petersburg this second criterion eliminated 10% of the original sample and for Orlando it eliminated 22% of the original sample.

A complete set of thirty bids were usable from only a tiny portion of all respondents. Individual bids (from usable surveys) were eliminated for the following reasons:

(1) bidding all zeros on one game eliminated the bids from that game. In St. Petersburg 9 respondents played only a WTA game and one played only a WTP game. In Orlando 14 respondents played only a WTA game and one played only a WTP game;

(2) bids were eliminated if they were irrelevant to the household's water use level, e.g., if the household did 2 cycles of laundry per week, their bid for 3 cycles was considered irrelevant (for the most part, respondents replied "does not apply" to these questions); and

(3) bids were eliminated if the respondent was indecisive or if the individual bid was otherwise rendered unusable by the aforementioned criteria which eliminated whole surveys.

The decision toeliminate bids was difficult because the initial survey design did not account for an exploration of the zero bid or the inconsistent bid. Yet neither could be dismissed indiscriminately because valid reasons could exist for both. Some respondents bid positive amounts for retaining lower levels of water use and zero for higher levels. It would appear to be inconsistent to, say, bid $3.00 to retain 10% of one's total water use and zero to retain 50%. Yet some respondents stated that they would seek an alternative source of supply if high percentages of their water use were threatened with price increases. Others stated that they could not afford the increases at higher levels. Both reasons were considered valid zero bids by the theoretical definition of value measurement that this study adapts.

Zero bids at lower levels of use were accepted because they usually indicated a willingness to comply with a reduction requirement only at that level. Unlike the surveys indicating only total compliance, this explanation is realistic and reasonable. Bids at the other extreme were too many standard deviations from the mean bids calculated for each equation and constituted outliers. As bids tended to be uniformly conservative this criteria eliminated very few bids. As expected most of the extremely high bids were in the WTA game.

In general, bids which could be explained and subsequently rendered reasonable were included in the sample. As stated the problem existed primarily with zero bids. Fortunately, with the St. Petersburg sample, bids were well explained and this aided in the process of determining whether or not a bid was usable. With the Orlando sample bids were not as well explained but proportionately fewer zero or inconsistent bids occurred.

Comparing WTP and WTA Within Use Categories

St. Petersburg Sample

Mean bids for each water use category increased as the amount of reduction avoided (or compensated for) increased (see Table 2). These results are consistent with the concept of a bid curve passing from the southwest quadrant through the origin into the northeast quadrant of Figures 2 and 3 (Chapter II).

Within the St. Petersburg sample the mean WTA bids for the total household water (w) category averaged 220% of their corresponding WTP bids. For the bath/shower (BS) category the mean WTA bids averaged 196% of the mean WTP bids. For the toilet flushing category the mean WTA bids averaged 113% of the corresponding mean WTP bids. These results are consistent with a hypothesis that WTA will normally be greater than WTP.

Table 2.--Mean bids

Use	Number of observations		Current price	Mean bid		Percentage bidding current price	
	WTP	WTA		WTP	WTA	WTP	WTA
St. Petersburg							
TF	96	104	1.90	2.80	3.09	55	47
TF	97	101	3.84	5.46	5.80	54	49
TF	92	100	5.76	8.42	10.38	61	48
BS	99	108	1.56	1.76	3.15	54	34
BS	97	107	2.34	2.87	5.32	53	36
BS	102	105	3.12	4.29	8.97	59	30
W	103	107	1.98	2.41	5.16	56	30
W	86	98	5.94	6.97	15.10	63	38
W	95	101	9.90	11.81	26.53	45	30
Orlando							
TF	51	60	2.16	2.00	4.34	31	33
TF	51	59	4.32	4.30	9.07	35	32
TF	45	60	6.36	6.71	15.31	44	32
BS	51	64	1.75	2.16	5.95	29	17
BS	51	59	2.63	3.06	8.91	45	17
BS	50	60	3.50	4.34	13.60	42	17
W	51	52	2.22	2.52	8.23	31	15
W	53	59	6.66	6.58	21.67	32	15
W	53	59	11.10	10.66	46.10	30	15

TF = Toilet flushing; BS = Bathing/showering; W = Total household water use

The Orlando Sample

Mean bids in the Orlando sample also increased as the amount of reduction avoided (or compensated for) increased (Figure 2).

Within the Orlando sample, mean WTA bids for the total water use category averaged 362% of the corresponding mean WTP bids. For the bath and shower category, the mean WTA bids averaged 293% of the corresponding mean WTP bids. For the toilet flushing category the mean WTA bids averaged 219% of the mean WTP bids.

Comparing WTP and WTA Between the Two Samples

It was hypothesized that the bids, for corresponding categories, would be higher in St. Petersburg because those respondents are familiar with water availability problems (Appendix II). However the sampled Orlando residents had a much higher mean income than the St. Petersburg group and this would tend to offset the difference in bids between the groups.

With respect to the total water use category (w), WTP, mean bids from St. Petersburg were roughly the same as for Orlando. However, for WTA, the Orlando mean bids averaged 158% of the corresponding St. Petersburg mean bids (Table 2).

With respect to the bathing and showering category, WTP mean bids from Orlando averaged 110% of those from St. Petersburg. But WTA mean bids from Orlando were about 169% of those from St. Petersburg.

With respect to the toilet flushing category of use, WTP bids from St. Petersburg averaged about 131% of those from Orlando. However, WTA mean bids from Orlando averaged about 147% of those from St. Petersburg.

In general, then, WTP bids were roughly comparable between the two samples, but WTA bids were consistently much higher from the Orlando sample.

Results of Regression Analysis

Willingness to Pay Equations

For the total water use category, the WTP dependent variables are WPWAT10, WPWAT30, and WPWAT50; for bath/showering use, WPBS20, WPBS30 and WPBS40; and for toilet flushing use, WPTF1, WPTF2, WPTF3. Each WTP dependent variable represents the amount the consumer is willing to pay through his monthly water bill to maintain current levels of household water for specific water-using activities, rather than experience a specified reduction in water use.

The independent variables in the WTP equations are NUMRESPH, INCOME, HAVEWELL, BELWSHRT, DECON50 and the quantity variables, AVGCON10, AVGCON30, AVGCON50, TOILQ1, TOILQ2, TOILQ3, BATHSQ20, BATHSQ30, BATHSQ40, each of which denotes the quantity reduction to which the bid pertains. The hypothesized relationship between these variables is discussed in Chapter

Four. Because of a high correlation between the variable, NUMRESPH, symbolizing the number of persons residing in a household, and the quantity variables, equations for both possibilities were presented.

Explanation of Results of WTP Regressions

The results of the regression analysis for WTP are summarized in Tables 3 and 4. Income was expected to be highly significant because it would appear intuitively to have a substantial influence on a consumer's willingness to pay. This variable was significant, in fact, in five equations in the St. Petersburg sample and in nine equations in the Orlando sample and in neither case did income play an important role in the WTP equations for total household water use. In St. Petersburg, income was significant in both WPBS20 and both WPBS40 equations. In Orlando income was significant in one WPTF1 equation, in both WTPF2 equations and in all WPBS equations. It appeared with the anticipated sign (positive) in all but two equations. The differences in the two samples may be attributed to the differences in mean income levels between the two city samples. In the St. Petersburg sample the mean income approaches \$10,000, while in the Orlando sample the mean income level approaches \$20,000.

NUMRESPH was also expected to be a highly significant variable. In St. Petersburg it appeared as significant in all equations in which it appears except WPBS40. In Orlando it did not appear as significant in any equation. The St. Petersburg sample had a higher mean household size than in Orlando and this may account for the difference, however, the differential is not large (2.5 in Orlando and 2.9 in St. Petersburg). NUMRESPH appeared with its expected sign (positive) in all St. Petersburg equations and in all but two, one WPWAT30 and in one WPWAT50, in the Orlando sample.

Originally HAVEWELL and KINDSYS were included in the total water use equations. KINDSYS was eliminated because it was not significant at any test level in any of the equations. HAVEWELL was retained but was significant in only one equation, WPWAT30, in the Orlando sample, where it appeared with a positive sign (its hypothesized sign was negative). In four out of six Orlando equations the HAVEWELL sign was positive. In the St. Petersburg sample HAVEWELL appeared consistently with the hypothesized sign but was not significant in any equation.

This variable was difficult to interpret and this may be the reason for its performance. Since most sampled households in St. Petersburg had a well its effect on the willingness to pay should be negative since this implies the existence of a substitute water system. However, this effect is apparently not substantial for the sample. On the other hand, the Orlando households, for the most part did not have a well and that fact had a positive effect on the willingness to pay for water. As with the St. Petersburg sample the presence of a well did not appear to have a substantial effect on the WTP.

The quantity variables were expected to have a negative effect on the WTP because they were entered into the equation as negative values, representing quantity reductions. (Actually the amount of water a household used was hypothesized to be a positive influence on the willingness to pay). They appeared in all equations (both samples) with the hypothesized

Table 3.--WTP regression results for St. Petersburg

WTP model	NUMRESPH	INCOME	HAVEWELL	BELWSHRT	DECON50	AVGCON10	AVGCON30	AVGCON50	TOILQ1	TOILQ2	TOILQ3	BATHSQ20	BATHSQ30	BATHSQ40	R2
WPWAT10 (a)	.180 (.185)	.122 (.164)	.299 (.447)	-.064 (.607)	-.252 (.652)										.028
WPWAT10 (b)		.119 (.163)	-.305 (.442)	-.043 (.603)	-.203 (.654)	-.867 (.736)									.031
WPWAT30 (a)	.333 (.247)*	.377 (.219)**	-.689 (.595)	-.049 (.808)	-.362 (.868)										.075
WPWAT30 (b)		.380 (.218)	-.723 (.588)	-.0004 (.804)	-.306 (.873)		-.464 (.327)								.076
WPWAT50 (a)	1.20 (.633)*	.537 (.562)	-.107 (1.53)	2.30 (2.07)*	-3.13 (2.23)*										.099
WPWAT50 (b)		.666 (.568)	-1.52 (1.53)	3.16 (2.09)*	-3.39 (2.27)			-.416 (.511)							.075
WPTF1 (a)	.624 (.198)***	.039 (.179)		-.008 (.666)	.755 (.714)										.093
WPTF1 (b)		.016 (.179)		-.022 (.663)	+.754 (.709)				-.003 (.001)***						.102
WPTF2 (a)	1.37 (.363)***	.202 (.329)		1.23 (1.23)	.035 (1.31)										.131
WPTF2 (b)		.247 (.329)		-1.21 (1.22)	.020 (1.31)					-.004 (.0009)***					.138
WPTF3 (a)	1.61 (.670)***	.234 (.610)		2.30 (2.25)	-.812 (2.41)										.073
WPTF3 (b)		.179 (.610)		2.27 (2.25)	-.823 (2.41)						-.003 (.001)***				.071
WPBS20 (a)	.152 (.114)*	.161 (.103)*		-.408 (.385)	-.319 (.412)										.050
WPBS20 (b)		.166 (.104)*		-.390 (.386)	.275 (.411)							-.0004 (.004)			.043
WPBS30 (a)	.395 (.195)	.215 (.177)		.553 (.659)	-.597 (.706)										.081
WPBS30 (b)		.206 (.176)		.545 (.657)	-.685 (.699)								-.001 (.0005)**		.087
WPBS40 (a)	.297 (.232)	.456 (.210)**		.766 (.784)	-.819 (.839)										.095
WPBS40 (b)		.430 (.208)**		.712 (.776)	-.860 (.827)									-.0008 (.0004)*	

*Significant at .10 level.

**Significant at .05 level.

***Significant at .01 level.

(a)Model with NUMRESPH.

(b)Model with quantity variable.

Table 4.--WTP regression results for Orlando

WTP model	NUMRESPH	INCOME	HAVEWELL	BELWSHRT	DECON50	AVGCON10	AVGCON30	AVGCON40	TOILQ1	TOILQ2	TOILQ3	BATHSQ20	BATHSQ30	BATHSQ40	R2
WPWAT10 (a)	.061 (.312)	.076 (.166)	.283 (.793)	.161 (.790)	-.791 (.849)										.023
WPWAT10 (b)		.086 (.154)	.308 (.803)	.230 (.827)	-.792 (.834)	-.109 (.428)									.02[illegible]
WPWAT30 (a)	-.167 (.542)	.260 (.287)	1.57 (1.37)	-.602 (1.37)	-3.68 (1.47)***										.129
WPWAT30 (b)		.194 (.263)	1.93) (1.37)*	-.38 (1.41)	-3.14 (1.42)**		-.333 (.243)*								.15[illegible]
WPWAT50 (a)	-.697 (1.06)	.160 (.560)	1.34 (2.68)	-1.77 (2.67)	-4.21 (2.87)*										.046
WPWAT50 (b)		-.049 (.514)	2.15 (2.68)	.968 (2.76)	-2.82 (2.78)			-.418 (.285)							.074
WPTF1 (a)	.077 (.249)	.232 (.132)		.784 (.625)	-1.13 (.676)*										.106
WPTF1 (b)		.231 (.133)**		.779 (.625)	-1.13 (.674)				.0004 (.001)						.106
WPTF2 (a)	-.100 (.445)	.456 (.235)**		.550 (1.12)	-1.34 (1.21)										.073
WPTF2 (b)		.428 (.239)**		.528 (1.12)	-1.24) (1.21)					-.00008 (.001)					.072
WPTF3 (a)	-.222 (.762)	.245 (.403)		-1.28 (1.92)	-.753 (2.07)										.018
WPTF3 (b)		.176 (.409)		-1.31 (1.92)	-.510 (2.07)						-.0002 (.001)				.018
WPBS20 (a)	.122 (.249)	.196 (.132)*		.671 (.626)	-1.15 (.677)**										.100
WPBS20 (b)		.199 (.132)		.679 (.626)	-1.19 (.665)							-.0005 (.001)			.098
WPBS30 (a)	.187 (.326)	.328 (.173)**		1.06 (.819*	-1.81 (.887)**										.141
WPBS30 (b)		.338 (.173)		1.07 (.820)	-1.87 (.870)								.0004 (.001)		.13[illegible]
WPBS40 (a)	.027 (.484)	.386 (.256)**		1.59 (1.22)*	-2.27 (1.32)**										.09[illegible]
WPBS40 (b)		.362 (.256)**		1:59 (1.21)	-2.21 (1.29)**									.0003 (.001)	.092

*Significant at .10 level.

**Significant at .05 level.

***Significant at .01 level.

(a) Model with NUMRESPH.

(b) Model with quantity variable.

sign and were significant in all St. Petersburg equations in which they appeared except for WPWAT10, WPWAT50, and WPBS20. In Orlando they were significant in WPWAT30 and WPWAT50 only.

The conservation variables performed differently than expected. BELWSHRT, the variable which registered belief in a water shortage was anticipated to be negative and appeared so in seven equations in both the St. Petersburg and Orlando samples. In eleven equations BELWSHRT was positive and this included the two cases in the St. Petersburg sample and the four cases in the Orlando sample in which the variable was significant. In Orlando BELWSHRT was significant in both WPBS30 and in both WPBS40 equations. In St. Petersburg, BELWSHRT was significant in both WPWAT50 equations.

DECON50 appeared as negative (its hypothesized sign) in twelve cases and as positive in 6 cases in the St. Petersburg sample. It was significant in the WPWAT50 equation where BELWSHRT was also significant. In the Orlando sample DECON50 had the expected sign in all equations except one, WPTF2, and was significant in eleven equations, both WPWAT30 equations, WPWAT50, both WPTF1 equations, and all WPBS equations.

Willingness to Accept Equations

In the WTA group of equations the dependent variables are WAWAT, WATF, and WABS which were creating from combining the WTA data sets of the total water WTA bid group, WAWAT10, WAWAT30, WAWAT50; the toilet flushing WTA bid group, WATF1, WATF2, WATF3; and the bath/showering WTA bid group, WABS20, WABS30, WABS40.

The independent variables are the same as in the WTP estimation with the exception of the quantity variables. The quantity variables, AVGCONT, TOILT and BATHST were created from the combination of their respective separate WTP data sets.

Description of Results of WTA Regression

The results of regression analysis for WTA equations are summarized in Tables 5 and 6. In the Orlando sample, income has the expected sign (positive) in all but one of the WATF and WABS equations. It was significant in only one WAWAT equation for the Orlando sample. In the St. Petersburg sample income was positive and highly significant in all equations.

NUMRESPH appeared in three equations for Orlando and each time with a negative sign (its hypothesized sign was positive). It was not significant in any equation which is similar to the results for this variable in the WTP equations for Orlando.

For the St. Petersburg sample, NUMRESPH was significant in two of the three equations in which it appeared and it was positive, as expected, in all three cases.

The quantity variables in the Orlando sample had the expected sign (negative) and significance in the three Orlando equations in which they appeared. Likewise they were negative and significant for all the relevant equations in the St. Petersburg sample.

Table 5.--WTA regression results for St. Petersburg

WTA model	NUMRESPH	INCOME	HAVEWELL	BELWSHRT	DECON50	AVGCONT	TOILT	BATHST	R2
WAWAT (a)	1.14	1.70	-1.99	2.74	.035				.038
	(.819)	(.732)***	(1.95)	(2.69)	(2.96)				
WAWAT (b)		1.45	-.723	2.25	2.20	-5.06			.184
		(.663)***	(1.77)	(2.46)	(2.72)	(.662)***			
WATF (a)	.679	.640		1.23	.459				.053
	(.281)***	(.257)***		(.950)	(1.04)				
WATF (b)		.573		1.03			-.003		.127
		(.245)**		(.909)			(.0005)***		
WABS (a)	.143	.601		1.04	.113				.030
	(.260)	(.238)***		(.880)	(.964)				
WABS (b)		.495		.855	.278			-.002	
		(.233)		(.860)	(.942)			(.0006)***	

*Significant at .10 level.

**Significant at .05 level.

***Significant at .01 level.

(a)Model with NUMRESPH.

(b)Model with quantity variable.

Table 6.--WTA regression results for Orlando

WTA model	NUMRESPH	INCOME	HAVEWELL	BELWSHRT	DECON50	AVGCONT	TOILT	BATHST	R2
WAWAT (a)	-1.34	1.67	-3.44	12.04	-10.58				
	(2.36)	(1.25)*	(5.99)	(5.97)	(6.42)**				.035
WAWAT (b)		1.07	.065	17.66	-5.48	-3.30			
		(1.09)	(5.69)	(5.97)***	(5.89)	(.706)***			.138
WATF (a)	-.274	.117		5.50	-3.43				
	(.789)	(.417)		(1.98)***	(2.15)*				.053
WATF (b)		-.293		5.27	-2.09		-.004		
		(.393)		(1.93)***	(2.04)		(.001)***		.099
WABS (a)	-.166	.311		3.12	-2.65				
	(.642)	(.339)		(1.61)**	(1.75)*				.030
WABS (b)		-.025		3.09	-1.74			-.004	
		(.324)		(1.58)**	(1.66)			(.002)***	.072

*Significant at .10 level.

**Significant at .05 level.

***Significant at .01 level.

(a)Model with NUMRESPH.

(b)Model with quantity variable.

The HAVEWELL variable in the Orlando sample was not significant in either equation in which it appeared and it appeared as a negative influence in one WAWAT equation and as a positive influence in the other equation.

In the St. Petersburg sample HAVEWELL was not significant in either of the total water WTA equations in which it appeared, however, it did appear with the expected sign (negative) in both cases.

The conservation variables for the WTA equations for the Orlando sample performed very much as they did for the WTP equations. BELWSHRT was consistently a positive variable and it was significant in all equations. DECON50 was consistently a negative variable and was significant in three equations, one WAWAT, WATF and WABS equation. In each of these equations NUMRESPH, rather than the corresponding quantity variable, was entered into the equation.

In the St. Petersburg sample BELWSHRT and DECON50 had positive signs in all equations and were consistently insignificant throughout.

CHAPTER VI

SUMMARY AND DISCUSSION

This study adapted a non-market valuation technique and applied it to the measurement of consumers' valuations of water in residential uses. Representative samples of single-family residential water customers were drawn from two major cities in Florida, and data for the study was acquired through the use of personal interviews following a specially designed questionnaire. The iterative questioning procedure of the survey was structured to elicit consumers' maximum willingness to pay to avoid specified reductions in residential water use, and, in addition, to elicit the minimum compensation necessary to induce consumers to voluntarily accept specified reductions in residential water use. Multiple regression analysis was used to test hypotheses concerning the role of selected independent variables as determinants of consumers' valuations of water in residential uses.

The results must be considered preliminary, since the initial analysis did not exhaust all possibilities for specifying the regression equations. Several conclusions can be drawn from the study:

(1) response of consumers to the contingent market, iterative bidding, context of the questionnaire indicated that a substantial percentage of the respondents understood the purpose of the questionnaire and attempted to honestly assess their willingness to pay and willingness to accept,

(2) mean bids for both samples, both measures (WTP and WTA), and all water use categories consistently demonstrated higher bids for greater contingent reductions in water use--a pattern which would produce bid curves passing from the southeast quadrant, through the origin into the northeast quadrant of a graph depicting a total value (or bid) curve,

(3) willingness to accept (WTA) bids consistently exceeded willingness to pay (WTP) bids for corresponding use reduction contingencies, and

(4) regression results suggest that a substantial portion of the hypothesized functional relationships between observed bids and selected explanatory variables were, in fact, statistically significant.

Additional investigation is needed in several areas:

(1) there is a need to further explore the ability of consumers to formulate valuations of water in household uses when such considerations are being made for the first time. Can "preparation" be provided without biasing consumers perceptions?

(2) The potential for other forms of bias must be carefully examined. While starting point bias was not expected to be a factor, it may well have existed. An alternated high and low starting point for bids within each sample could be applied to test for the presence of starting point bias.

(3) It was hypothesized that the variables which influence the willingness to pay for water would be the same as those which influence the amount of use. The theoretical underpinnings of these hypotheses need to be developed with greater care.

(4) Empirical estimation of a bid function must require a zero intercept in order that the estimated function retain the properties inherent in its definition.

APPENDIX I

THE QUESTIONNAIRE

1. How many persons presently live in this household?____________________

2. How many members of your household, including yourself, are in each age group?

   __________ 0-10 years __________11-20 years __________21-40 years

   __________41-60 years __________over 60 years

3. Do you own or rent your home? _____own _____rent

4. If own, what is the market value of your property?__________If rent, what is your rent/month?

5. How long have you lived in the St. Petersburg area? _____years

6. How old is your home? ______________

7. Place of previous residence? __________________city ___________state

8. Do you live in Florida year-round?

   ___________yes

   ___________no

   If no, what months do you spend in Florida?

   from _________ to __________

9. Is the head of the household employed, retired or unemployed?

   ___________ unemployed

   ___________ retired

   ___________ unemployed

   If employed, what is his/her occupation? ____________________________

10. What are the occupations of other working members of the household?

    ____

11. What is the highest grade of school completed by the head of the household?

    ______________less than high school

    ______________high school

    ______________some college or technical

    ______________B. A. or B. S.

    ______________Masters or Ph.D.

12. What is the number of overnight guests in your home per year?

_________ 0-10

_________ 11-20

_________ 21-30

_________ over 30

Their average length of stay is

_________ 1 day

_________ 2-7 days

_________ 1-2 weeks

_________ 2-4 weeks

_________ over 1 month

13. How many of the following water using appliances does your household have?

_________ bathtubs

_________ toilets

_________ washing machines

_________ dishwashers

_________ showers (with and without bathtubs)

_________ sinks

_________ garbage disposals

_________ other (hot tubs, jacuzzi, etc.)

14. Do you have a swimming pool?

_________ yes

_________ no

15. Do you use bottled water?

_________ yes

_________ no

If yes, how many gallons per month?

_________ gallons

16. Do you have a home water softener?

_________ yes

_________ no

17. Do you have a septic tank?

_________ yes

_________ no

18. Do you have a private well?

_________ no

_________ yes

_________ yes, but only for lawn sprinkling

19. What kind of system do you use to water your lawn or garden?

_________ none

_________ hose and sprinkler(s)

_________ automatic sprinkler system

20. Estimate the size of your property:

_________ Less than 1/10 acre

_________ 1/10 acre

_________ 1/5 acre

_________ 1/4 acre

_________ 1/2 acre

_________ 3/4 acre

_________ 1 acre or more

21. How often do you wash your car(s) at home?

_________ less than once a month

_________ 1 to 3 times a month

_________ more than 3 times a month

22. What is your total monthly water bill in dollars: _________

_________ for water only

_________ for sewer/wastewater only

23. What is an estimate of how much water your household uses each month?

__________ gallons

__________ do not know

24. Indicate in which period your water bill is the highest:

__________ January - March

__________ April - June

__________ July - September

__________ October - December

25. What is the combined income of your household?

__________ less than 5,000.

__________ 5,000 to 9,999.

__________ 10,000 to 14,999.

__________ 15,000 to 19,999.

__________ 20,000 to 24,999.

__________ 25,000 to 29,999.

__________ 30,000 to 34,999.

__________ 35,000 to 39,999.

__________ over 40,000.

The following tables provide a water use estimate for your household. Please indicate the frequency for each use category (how many times it is done) in column 2. Column 3 provides approximate amounts of water used by each item.

1 Item	2 Use per week	3 Gallons per item	4 Total
a. Automatic dishwasher		12	
b. Hand dishwashing		8	
c. Clothes washing (cycles or loads)		50	
d. Hours of lawn watering (see below)		500	
e. Garbage disposal (2 minute use period)		6	
Subtotal			
	Use per day		
f. Shower		33	
g. Bath		30	
Subtotal			
	No. of persons	Gallons per day	
h. Toilet flushing		32	
i. Cooking and drinking		3	
Subtotal			
Total			

Please indicate the months within which you water your lawn at least once a week:

____

Part Three
Iterative Bid

(Note to Surveyors:
THIS SCENARIO IS HYPOTHETICAL! NO SUCH REQUIREMENTS ARE PENDING FOR CONSUMERS).

Supplying water in the future may require higher than present costs. Imagine that a water planning agency has to pay higher costs to provide enough water, and is interested in finding out their consumers' willingness to pay these higher costs for current use levels.

Please indicate your willingness to pay through changes in your monthly water/sewer bill for water in specific uses. Imagine that requirements are set for water use reductions but you may avoid compliance if you are willing to pay to do so. (The first amount presented is the current price for the amount of water given).

A. Lawn watering

1. If there was a requirement to reduce lawn watering by 1/2 hour a week, how much additional money would you be willing to pay to avoid complying with this requirement?

$1.98 $3 $4 $6 $8 $12 $16 $24 ______ other

2. To avoid reducing lawn watering by 1 hour?

$3.96 $6 $8 $12 $16 $24 $32 $48 ______ other

3. To avoid reducing lawn watering by 3 hours?

$11.88 $16 $24 $32 $48 $72 $95 $143 ______ other

B. Toilet Flushing

1. If there was a requirement to reduce toilet flushing by 1 time per person per day, how much additional money would you be willing to pay to avoid complying with this requirement?

$1.90 $3 $4 $6 $8 $11 $15 $23 ______ other

2. To avoid reducing toilet flushing by 2 times per person?

#3.84 $6 $8 $11 $15 $23 $31 $46 ______ other

3. To avoid reducing toilet flushing by 3 times per person per day?

   $5.76 $9 $12 $18 $23 $35 $46 $70 ______ other

C. Bath/Shower

1. If there was a requirement to reduce bath/shower usage in the household by 20%, how much additional money would you be willing to pay to avoid complying with this requirement?

   (a 20% decrease is equivalent to a person taking six showers a week instead of seven, or reducing a 10 minute shower to 8 minutes).

   $1.56 $3 $5 $6 $9 $12 $19 ______ other

2. To avoid reducing bath/shower usage by 30%?

   $2.34 $4 $5 $7 $9 $14 $19 $28 ______ other

3. To avoid reducing bath/shower usage by 40%?

   #3.12 $5 $6 $9 $12 $19 $25 $37 ______ other

D. Clothes Washings

1. If there was a requirement to reduce clothes laundry use by 2 cycles or loads per week, how much additional money would you be willing to pay to avoid complying with this requirement?

   $.79 $2 $3 $5 $6 $9 ______ other

2. To avoid reducing laundry use by 3 cycles or loads per week?

   $1.19 $2 $4 $5 $8 $10 $14 ______ other

3. To avoid reducing laundry use by 4 cycles or loads per week?

   $1.58 $3 $4 $6 $10 $13 $19 ______ other

E. What are you willing to pay to avoid a reduction of 10% of all water usage for your household?

$1.98 $3 $4 $5 $8 $12 $16 $24 $36 ______ other

2. To avoid a reduction of 30% of all water usage for your household?

$5.94 $9 $12 $18 $24 $36 $48 $72 $96 ______ other

3. To avoid a reduction of 50% of all water usage for your household?

$9.90 $15 $20 $30 $40 $60 $80 $120 $160 ______ other

If you had decided to comply with requirements of water use reduction what amounts would you consider necessary to compensate you for the inconveniences which you incur when you make these reductions?

Please indicate the minimum amount of money which you would accept, through reductions in your monthly water bill, for specific water uses. (The first amount presented is the current price for the amount of water given).

A. Toilet Flushing

1. If you were required to reduce toilet flushing <u>1 time per person per day</u>, what amount would fully compensate you for your loss?

$1.90 $3 $4 $7 $9 $13 $17 $26 ______ other

2. For a loss of 2 times per person per day?

$3.84 $6 $8 $11 $15 $23 $31 $46 ______ other

3. For a loss of 3 times per person per day?

$5.76 $9 $12 $18 $23 $35 $46 $70 ______ other

B. Lawn Watering

1. If you were required to reduce lawn watering by 1/2 hour a week, what amount would fully compensate you for your loss?

$1.98 $3 $4 $6 $8 $12 $16 $24 ______ other

2. For a loss of 1 hour a week?

$3.96 $6 $8 $12 $16 $24 $32 $46 ______ other

B. (continued)

3. For a loss of 3 hours a week?

$11.88 $16 $24 $32 $48 $72 $95 $143 ______ other

C. Bath/Shower

1. If you were required to reduce bath/shower usage in the household by 20%, what amount would fully compensate you for your loss?

(a 20% decrease is equivalent to a person taking six showers a week instead of seven; or reducing a 10 minute shower to 8 minutes).

$1.56 $3 $5 $6 $9 $12 $19 ______ other

2. For a loss of 30% of your current bath/shower use?

$2.34 $4 $5 $7 $9 $14 $19 $28 ______ other

3. For a loss of 40% of your current bath/shower use?

$3.12 $5 $6 $9 $12 $19 $25 $37 ______ other

D. Clothes Washings

1. If you were required to reduce your laundry use to <u>2 cycles or loads a week</u>, what amount would compensate you for your loss?

$.79 $2 $3 $4 $5 $6 $8 $10 ______ other

2. For a loss of 3 cycles or loads a week?

$1.19 $2 $4 $5 $8 $10 $15 ______ other

3. For a loss of 4 cycles or loads a week?

$1.58 $3 $4 $6 $10 $13 $19 ______ other

E. If you were required to reduce all of your household water usage by 10% what amount would fully compensate you for your loss?

$1.98 $3 $4 $5 $8 $12 $16 $24 $36 ______ other

E. (continued)

2. For a loss of 30% of all your household water usage?

$5.94 $9 $12 $18 $24 $36 $48 $72 $96 ______ other

3. For a loss of 50% of all your household water usage?

$9.90 $15 $20 $30 $40 $60 $80 $120 $160 ______ other

Part four: CAS

1. During the recent years, the media has been reporting the existence of water shortages in many areas of the United States. These shortages place pressure on urban water supply systems which provide water for residential home use.

   Do you believe a water shortage exists in the St. Petersburg area?

   ______ No

   ______ Yes

   If yes, how serious would you say the water shortage is in St. Petersburg at present?

   ______ very serious

   ______ fairly serious

   ______ not serious

   ______ do not know

2. Whether or not you believe that there currently is a water shortage in your area, do you believe that there will be such a problem in the future? Please indicate by what year you think a water shortage may become a problem or continue to be a problem?

   ______ 1981

   ______ 1985

   ______ 2000 or beyond

   ______ never

3. If you believe a water shortage exists or will exist in St. Petersburg, to what extent do you believe each of the following to be a cause of the problem?

	Great Extent	Some Extent	Not at all
(a) Natural causes:			
1) lakes, rivers drying up	______	______	______
2) lack of rainfall	______	______	______
3) depleting groundwater sources (includes salt water intrusion).	______	______	______
(b) Man made causes:			
1) growth of population in St. Petersburg area	______	______	______
2) growth of population in other areas	______	______	______
3) increased water usage per person due to increased use of water-using home appliances (i.e. hot tubs)	______	______	______

3. (continued)	Great Extent	Some Extent	Not at all
4) increased water due to wasteful practices	______	______	______
5) the heavy use of water for commercial (industry, mining)	______	______	______
6) the heavy use of water for agricultural activity	______	______	______
7) pollution of water supplies	______	______	______

(c) Institutional causes:

1) Water utilities have not taken the necessary steps to provide for enough water for residential use.	______	______	______

4. In some areas throughout the country the public has been asked to practice water conservation in order that water demand may be reduced. Water conservation can be achieved in numerous ways. Following is a list of possible conservation practices. Please indicate to what extent you believe each practice may result in conserving water:

	Great Extent	Some Extent	Not at all
a) Filling the bathtub only one-fourth full	______	______	______
b) Turning off the water while brushing your teeth and shaving	______	______	______
c) Taking showers in a shorter amount of time	______	______	______
d) Using the dishwasher only when it is full	______	______	______
e) Cutting back on lawn sprinkling time	______	______	______
f) Cutting back on times the toilet is flushed	______	______	______
g) Capturing and reusing shower water for non drinkable use (e.g., plant watering)	______	______	______

4. (continued)

	Great Extent	Some Extent	Not at all
h) Placing a brick in the toilet tank	____	____	____

i) Use of the following water saving devices:

	Great Extent	Some Extent	Not at all	Are not familiar with
1) pressurized showerheads	____	____	____	____
2) suds-saving washing machine	____	____	____	____
3) shallow trap water saving toilets	____	____	____	____
4) chemical toilets	____	____	____	____
5) low volume dishwasher	____	____	____	____
6) dual flush toilet tank	____	____	____	____
7) washerless faucets	____	____	____	____

5. Which of the following conservation practices are you actually using to reduce the amount of water your household uses? Please indicate whether you are making large efforts, medium efforts, small efforts, or no effort in each of the areas listed below:

	Large Effort	Medium Effort	Small Effort	No Effort	Does Not Apply
a) turning off the water while brusing your teeth and shaving	____	____	____	____	____
b) using the dishwasher only when it is full	____	____	____	____	____
c) taking showers in a shorter amount of time	____	____	____	____	____
d) cutting back on lawn sprinkling time	____	____	____	____	____
e) filling the bathtub only one-fourth full	____	____	____	____	____
f) cutting back on times the toilet is flushed	____	____	____	____	____
g) capturing and reusing shower water for non-drinkable use (e.g., plant watering)	____	____	____	____	____
h) placing a brick in the toilet tank	____	____	____	____	____

i) use of the following water saving devices:

	Yes	No
1) pressurized showerheads	____	____
2) suds-saving washing machines	____	____
3) shallow trap water saving toilet	____	____
4) chemical toilet	____	____
5) low volume dishwasher	____	____
6) dual flush toilet tank	____	____
7) washerless faucets	____	____

6. In some areas the price of water (per 1,000 gallons or per cubic feet) has been increased with the belief that water usage will decrease as a result. In your area has the price of water/sewer recently (last few years) been increased?

_________ No

_________ Yes

If yes, has this price increase led to a reduction of water usage in your household?

_________ No

_________ Yes

7. Do you anticipate an increase in the price of water/sewer for your area in the near future (within the year)?

_________ No

_________ Yes

8. Do you think that your household would decrease its water usage if the price of water/sewer was raised by 50%?

_________ No

_________ Yes

If yes, by approximately what percent would your household decrease its water usage:

_________ 0-10%

_________ 11-20%

_________ 21-30%

_________ over 30%

9. Do you think that your household would decrease its water usage if the price of water was raised by 100%?

_________ No

_________ Yes

If yes, by approximately what percent would your household decrease water usage?

_________ 0-10%

_________ 11-20%

_________ 21-30%

_________ over 30%

10. If you would decrease your water usage would you do so with the installation of water saving devices?

_________ Yes, I would consider immediate installment.

_________ Yes, but only when I needed a new toilet, sink, etc.

_________ No.

APPENDIX II

THE SAMPLE

This study required the drawing of two separate samples, one from the city of Orlando, Florida and one from the city of St. Petersburg, Florida. The qualifications for the population were: a) it was confined to the geographic areas under the jurisdiction of the water utility which served the largest number of customers. The reasons for this were the need to deal with one rate and the need to represent as large an area as possible within the city itself. The two water companies used, Orlando Utilities Commission (OUC) in Orlando and St. Petersburg Public Utilities in St. Petersburg, both had one residential rate structure which extended to the city limits (see Table 7); b) it was confined to single family dwellings with 5/8 inch water meters. This was because apartment residents often do not pay their own water bills and because meters of different size follow differing rate structures. Although the construction of multi-unit dwellings is increasing, the majority of housing structures in both Orlando and St. Petersburg are single-family units.

This appendix contains two sections. The first section provides an introduction to the communities selected, including a brief description of their water supply systems, the status of their water reserve capabilities, and a discussion of the demographic characteristics which influence the demand for residential water in both communities. In the second section of this appendix, a detailed review of the sampling procedure is presented.

Community Characteristics

St. Petersburg (Pinellas County)

Demographic characteristics

Pinellas county is the most densely populated of all Florida counties. Current density in developed residential areas of Pinellas county is 14 persons per acre or 5.83 units per residential acre (Board of County Commissioners, 1973). The density for the total county is 3.6 persons per acre with a unit density of 1.5 units per acre. If the county continues to grow at the rate set since the Census of 1970, the estimated population in year 2000 would be over 1.8 million.

From 1940 to 1979 the population increased at the annual average rate of 72% (Pinellas Planning Council, 1978). St. Petersburg accounted for about 39% of the county's total population in 1970 and the growth rate of its population has been recently somewhat lower than for the rest of the county. The immigration rate is largely responsible for the increase, adding to the population about six times faster than the birth rate. During the sixties immigration averaged a moderate rate of 14,800 persons annually. Between 1972-1975 the annual rate jumped to 32,600 and recently averages about 12,000 persons a year. Most of the immigrants are in the older age groups. More than one-third of the current population have lived in Pinellas County for less than five years.

Table 7.--Water rate schedules for sampled cities.

ST. PETERSBURG WATER RATE SCHEDULE
(for 5/8 inch meter within city limits)

Service/Price	Base Rate	Price per 1,000 gallons
Water	$1.75	$.72
Wastewater	$2.95	$.79*

*Maximum charge for wastewater to single family residences is $14.85.

ORLANDO WATER RATE SCHEDULE
(for 5/8 inch meter within city limits)

Service/Price	Base Rate	Cost per 1,000 gallons		
		First 1,000	2,000-100,000	over 100,000
Water	-	$1.88	$.44	$.37
Wastewater	$1.75	$1.45	$1.45	$1.45

The characteristics of the incoming population mirror the characteristics of the general population (Bureau of Economic and Business Research, 1980). In Pinellas County the percentage of persons in specific groups have increasingly been weighed toward the older categories. In 1950 the percentage of the population over age 65 was 19%; in 1975 that percentage nearly doubled to 34%.

The large component of older persons in Pinellas county accounts for several other demographic attributes. Median education levels tend to be low, according to the 1970 census, 77% of the population completed equal to or less than a high school education (Pinellas Planning Council, 1978). Income averages had kept pace with the national averages until 1974 but have been growing more slowly in the last five years. Per capita income in 1975 for St. Petersburg was $5,817 (Pinellas Planning Council, 1977). Household income which averaged $12,395 in 1976 for the county is expected to increase by 48% to $18,318 by 1981.

The older population also helps explain the average household size and type of housing structure statistics. Both a rising death rate and a high rate of immigrating retirees contribute to an average household size which is below the state average by 16% and the national average by 22%. In 1950 the average household size in Pinellas county was 2.71, in 1975 it was 2.43. There is a high percentage of one and two person households with one person households alone accounting for 11% of all county households. Other trends which contribute to this are the declining birth rate, increasing divorce rates and the tendency for young adults also to form single-person households.

There has been a more intense development of multi-unit dwellings to accomodate the demand for single person units. In 1970 in the city of St. Petersburg alone, the construction of multi-unit dwellings exceeded the single-unit dwellings by 228%. In 1975 this trend was reversed but again in 1979 the multi-unit percentage exceeded the single-unit by 300%. In 1977 the inventory of housing indicated that single-unit residences accounted for 56%, multi-unit residences accounted for 32%, and mobile homes accounted for 12% of the total housing structures. The average facility size of apartments tends to be small, 63% of the total number have one bathroom (Pinellas Planning Council, 1978).

Water supply and demand characteristics

St. Petersburg receives its water from its own municipal system which draws from the Floridan aquifer through well fields in Pasco and Hillsborough counties. The number of wells has increased from 24 in 1963 to 35 in 1980.[11] Average daily pumpage rates have been increasing from 20 million gallons in 1956 to 35 million gallons in 1975. Demands upon the system have been growing, serving a population of 250,000 in 1970 and 283,000 in 1980. Per capita daily use (GPCD) has risen from 130 gallons in the late sixties to

[11] Telephone communication with Dean Hughes, St. Petersburg Public Utilities, St. Petersburg, Florida, November 6, 1980.

nearly 140 gallons in 1975 (Healy, 1977). Projections for Pinellas county indicate that by the year 2000 the GPCD will increase to 151, with the country water systems requiring more than twice the amount of water that they now distribute (Southwest Florida Water Management District, 1978). The months of highest demand have been consistently April-May and the low periods are December-February (Healy, 1977).

The remainder of Pinellas county is served by the Pinellas County Water System. Together with the St. Petersburg Public Utilities these systems have had shortage problems through the 1970's. The principal causes for the scarcity are 1) since 1961 the geographic area of the SWFWMD had experienced a critical lack of rainfall (Parker, 1975). Consequently the aquifer was losing its chief source of recharging water. This resulted in 2) excessive pumping of the available groundwater reserves further lowering the area's water table. Excessive pumping was the natural result of growing demand pitted against a depleting supply. Rising demands were caused by a large immigrating population and also the prodigious water requirements of the citrus and phosphate industries. The next problem in the cycle is 3) the lowering of fresh water preserve yielded to salt water intrusion into groundwater sources.

In 1973 the Southwest Florida Water Management District (SWFWMD) regulated St. Petersburg's wells to provide more water to the Pinellas County system until the latter could augment their capacity. Both systems were severely taxed and an official water crisis with restrictions was declared (Board of County Commissioners, 1973).

Since then the Pinellas County Water System has increased its number of wells from 45 to 64. St. Petersburg has increased their total supply to 35 production wells.

Orlando (Orange County)

Demographic characteristics

Orlando which is located in Orange county has a high density of 400 persons per square mile. Its suburban county, Seminole, has a density of over 700 persons per square mile (Bureau of Economic and Business Research, 1980). The population of Orange county estimated for 1979 is 441,337 with the city of Orlando accounting for 28% of the total population. The population of Orlando has been increasing since 1940 at an average annual rate of 61%. Orange county has experienced a net migration average rate of about 4,300 persons annually between 1960 and 1970. Persons in age groups of 10-60 years account for 75% of this figure. The age group of 60+ years accounts for 19% of net migration. In contrast to Pinellas county new residents are primarily from the younger age categories (Bureau of Economic Analysis, 1979).

The distribution has not changed significantly in the past twenty years in either Orange or Seminole counties however, the number of persons in the 0 - 14 years of age has been declining. In 1978 in Orange County 45% of the population fell into the 15-44 age category, 22% fell into the 45-64 age category and 11% fell into the 65+ category (Bureau of Economic and Business Research, 1980).

According to the 1970 Census 57% of the Orange County residents had completed a high school education. Due to the increased urbanization since that time this percentage has most likely increased (Orlando Chamber of Commerce, 1978). Median family income in 1969 was $8,880 and had increased by 22% to $10,832 by the mid seventies. Per capita income in 1976 was $5,123. Average household income was $14,719 in 1976 and it is expected to increase by 50% to $22,062 by 1981.

Housing characteristics in Orange County differ from Pinellas although not too drastically. Due to the younger population the average household size is larger than in Pinellas County, in 1970 it was 2.06 and in 1975 it was 3.02 persons (Orlando Chamber of Commerce, 1978). In a 1970 housing inventory of 109,000 households, 76% were single-unit residences and 17% were multi-unit. In 1975, the number of households increased to 140,000 with the percentage and multi-unit percentage increasing to 30%. In both years the percentage of mobile homes averaged 5.8% of the total. Between the years 1971-1974 construction starts for multi-unit structures for outweighed single unit dwellings. However, since 1975 the construction of single-unit structures has been greater. In absolute figures the construction activity of both periods differs substantially: between 1971-1974 single-unit construction averaged 381 units annually while multi-unit construction averaged 2,756 units annually. Between 1975-1977 single-unit construction averaged an annual 289 units and multi-unit construction averaged an annual 30 units.

Water supply and demand characteristics

Orlando receives its water from its own municipal system which draws from the Floridan aquifer through well fields throughout Orange County (Healy, 1980). The number of wells has increased from 18 wells in 1970 to 23 wells in 1980. Until 1956 surface water from nearby lakes was utilized; since then the supply has been exclusively groundwater. Average daily pumpage rates have increased from 15 million gallons in 1956 to 41 million gallons in 1975. Demands have been increasing; population served in 1970 was 175,000 and in 1980 it was well over 200,000. Per capita daily water use has increased from 185 gallons in 1970 to 208 gallons in 1975. Generally the period of the highest seasonal demand is April-May, the lowest demand occurs during February.

Orange County is, for the most part, a water abundant area. The effect of increasing urbanization, however, has since the 1960's begun to change the quantity, and the quality of the available reserves. The major source of aquifer recharge is rainfall, less of which is reaching the groundwater supplies due to manmade surfaces. Also, contact with such surfaces is causing an increase of pollutants recharged into the aquifer. Urbanization trends also create an increase in demand. It is expected that by 1985 water withdrawals will equal the water recharged. By 1990 it is anticipated that the former may exceed the latter by 10%, i.e., water will be "mined" in Orange County. The result of this could be severe contamination of the aquifer through intruding salt water (East Central Florida Regional Planning Council, 1977; and St. John's River Water Management District, 1977).

The inland areas of Florida have water shortage problems which cannot compare in severity with those of the coastal cities. Despite the above caveats, Orlando itself is situated close to several of the most productive recharge areas in the Floridan aquifer (East Central Florida Regional Planning Council, 1977). So far water shortages which warrant limitations on residential consumer consumption have not existed.

Sampling Procedure

The population of the two communities, when adjusted to include only single family dwellings with 5/8-inch water meters was approximately 74,900 households in St. Petersburg and 25,000 in Orlando. Due to the high cost of collecting observations the sample sizes were limited to a total of 312 sampling units, or households.[12]

The procedure followed was a combination of stratified and cluster sampling (Scheaffer, et al., 1979, Chapters 5 and 7). The reason for using both was to insure the lowest cost for the greatest amount of variability in the major independent variables. The personal interview, selected as the mode of data gathering, is very expensive. Travel costs were cut by "clustering" the sample respondents into various separate areas of the sample geographic area. The sample was stratified into three groups characterized by high, medium and low levels. This insured that the cluster of the respective incomes were chosen from all three in the proportion in which they exist in the population.

The census tract was used as the primary cluster unit and the census block as the secondary cluster unit. Census tracts were categorized into income groups according to that group which constituted the highest percentage of the households in the tract.[13] The results of this procedure, listed in Table , indicated that in St. Petersburg 5% of the sample would be drawn from 3 census tracts, 32% from 15 tracts, and 63% from 38 tracts. In Orlando, 1% would be drawn from 1 tract, 66% from 15 tracts, and 33% from 6 tracts. Census tracts are not of uniform size. In St. Petersburg the tract sizes range from 377 to 1901 households, and in Orlando they range from 111 to 2,099 households.

The sample required 100 households from Orlando and 150 from St. Petersburg. The marketing research firms responsible for executing the

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[12]Personal interviews for each sampling unit cost $9.25 in St. Petersburg and $9.34 in Orlando. The interviews were conducted by private marketing research firms.

[13]Household counting was made prior to adjusting the population by the qualifications indicated by (b) on page one. Census data was used from 1970. Updates of census information for income and household counts was available for St. Petersburg from the Economic Base Study, Pinellas County, 1977, and the Demographic Study, Pinellas County, 1978; and for Orlando from the Orange County Economic Data, 1979.

Table 8.--Number of census tracts and households in each income group.

ST. PETERSBURG

Income groups	No. of tracts	%	No. of Households
High - over $15,000	3	5	2,863
Medium - $7,000 - $15,000	15	32	19,374
Low - under $7,000	38	63	37,740
TOTAL	56	100	59,977

ORLANDO

Income groups	No. of tracts	%	No. of households
High - over $15,000	1	1	175
Medium - $7,000 - $15,000	15	66	11,491
Low - under $7,000	6	33	5,782
TOTAL	22	100	17,448

survey requested that "around 500 households be provided in each city. To keep proportions even, 500 were provided in Orlando and 66 were provided in St. Petersburg. To maintain the proper proportions the 500 households (in St. Petersburg) were divided as follows: 25 from the high income group, 160 from the medium income group, and 315 from the low income group. In Orlando the 500 households were divided as follows: 5 from the high income group, 330 from the medium group, and 165 from the low income group.

Census tract maps were provided by the city planning departments of St. Petersburg and Orlando. To use every census tract would not have alleviated the travel cost problem. Therefore the number of tracts used in St. Petersburg was divided by three and in Orlando it was divided by two (see Table 8). This decrease in the number of tracts selected caused the size of each cluster (tracts) actually used to increase. Usually this is not desirable if homogeneity within a cluster is anticipated. In this case, however, variability is insured because clusters (tracts) were chosen independently in the three different income groups. The proportions of income groups in the population was maintained by dividing each income group of census tracts by the same number. The required number of tracts per income group was then selected by simple random sampling.

The next step was to select blocks from within the chosen census tracts. The geographic boundaries of each tract were demarcated on a city street map. The blocks were listed and selected through simple random sampling. Within each income group the number of households was divided by the number of tracts yielding the number of households required within each tract (see Table 9). This number divided by the number of households residing on a block in each tract would give the number of blocks required per tract. There is certainly no uniformity among city blocks, however, on a tract by tract basis, this resulted in a range of 2-4 blocks per tract which were to be canvassed.[14]

The average tract in St. Petersburg was more dense than its counterpart in Orlando although the range of the household count per tract is broader in the latter. Consequently the tract number is less in St. Petersburg. While it would seem likely that the number of households per tract would be higher in St. Petersburg, the differential between household counts in the high income group accounts for a higher number of households per tract in Orlando.

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[14]Accurate counts of total housing units and their types (e.g., single-family, multi-family, etc.) can be obtained for each block in a census tract through the Block Statistics, 1970 Census of Housing. However this data is computerized and was prohibitively expensive to obtain. Once a first block in a tract was chosen its size was used to determine whether another block was needed (after accounting for the presence of apartments and commercial establishments). In all cases the tracts required at least two blocks. Four blocks was the most that any tract required.

Table 9.--Number of households per census tract, by income level.

ST. PETERSBURG

Income level	Number of tracts	Number of households	Number of households per tract
High	1	25 (33)	25 (33)
Medium	5	160 (213)	32 (43)
Low	13	315 (420)	24 (32)
Total	19	500 (666)	-

ORLANDO

Income level	Number of tracts	Number of households	Number of households per tract
High	1	5	5
Medium	14	330	47
Low	7	165	41
Total	22	500	-

Blocks were selected by simple random sampling. Chosen blocks were located in the 1979 city directories of both cities. All names (of the head of the household) were listed with the corresponding street addresses. A member of each of these households then became a potential respondent.

Since many more households were provided than were required, each tract had to be designated with the number necessary for the actual sample. This was acquired by taking the number of total households necessary in each tract group and dividing it by the number of tracts in that group. In each group a percentage increase was given to account for responses which cannot be used. For St. Petersburg an extra 32 were provided and for Orlando an extra 30 surveys were provided for this purpose.

APPENDIX III

SUPPLEMENTAL SUMMARY OF QUESTIONNAIRE RESULTS

The questionnaire which was administered in order to elicit individual valuations of residential water use also contained supplementary questions about socioeconomic characteristics of the sampled households, and about the attitude, beliefs, and practices with regard to the water use of households. Discussion of formal research results did not include much of this information. It is the purpose of this appendix to summarize those supplementary questionnaire results.

Table 10.--Socioeconomic data

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
1. NUMRESPH: number of persons in a household	1	11	18
	2	37	32
	3	16	18
	4	24	13
	5	11	10
	6	0	7
	7	0	2
2. AG0T10: household members of age 0 to 10 years	0	68	77
	1	15	15
	2	13	4
	3	13	2
	4	5	2
3. AG11T20: household members of age 11 to 20 years	0	74	64
	1	15	19
	2	8	11
	3	3	3
	4		2
	5		1
4. AG21T40: household members of age 21 to 40 years	0	58	51
	1	13	20
	2	27	22
	3	2	7

Table 10.--Socioeconomic data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
5. AG41T60: household members of age 41 to 60 years	0	55	74
	1	18	13
	2	27	13
6. AG60: household members of age 60 and over	0	66	54
	1	19	24
	2	15	22
	3		1
7. SYRSCOM: highest level of education attained by head of household			
	less than 12 yrs.	15	17
	12 yrs.	35	42
	some college/tech	21	22
	B.A.,B.S.	16	16
	M.S./Ph.D.	13	4
8. OWNRENT: own or rent home	own	89	91
	rent	11	9
9. MARKTVAL: market value of home			
	0 - $30,000	20	24
	31 - $50,000	22	42
	51 - $80,000	22	15
	over $80,000	4	4
	no answer/do not know	32	15

Table 10.--Socioeconomic data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersurg
10. HOMEAGE: age of home in years			
	0 - 10	11	15
	10 - 20	37	16
	20 - 30	36	38
	30 - 50	10	17
	over 50	0	12
	no answer/ do not know	6	2
11. SIZEAREA: estimated size of property			
	less 1/5 acre	8	26
	1/5 - 3/4 acre	62	64
	3/4 - 1 acre	2	7
		26	2
12. INCOME: yearly household annual income			
	less $5,000	5	0
	$5 - $9,999	16	16
	$10 - 14,999	13	21
	$15 - 19,999	18	27
	$20 - 24,999	13	11
	$25 - 29,999	10	15
	$30 - 34,999	10	4
	$35 - 39,999	3	4
	over $40,000	13	2

Table 10.--Socioeconomic data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
13. OCCUPATION:			
	professional, technical	13	12
	managerial, administrative	16	12
	sales	10	4
	clerical	12	14
	craftsmen	2	5
	operative, laborer, service	8	4
	farm personnel	2	4
	retired	33	41
	unemployed	3	4
14. WASHCAR: frequency of carwashing			
	less once monthly	47	51
	1 - 3 times monthly	39	30
	more 3 times monthly	15	5
	no answer		13
15. SWIMPOOL: presence of swimming pool			
	yes	16	10
	no	84	90
16. BOTTWAT: use of bottled water			
	yes	95	7
	no	5	93

Table 10.--Socioeconomic data--Continued

Question	Response category	Percentage in response category: Orlando	St. Petersburg
17. SEPTICT: presence of a septic tank	yes	5	4
	no	95	96
18. HAVEWELL: presence of a private well	yes	3	8
	yes, for lawn watering only	19	61
	no	77	31
19. KINDSYS: kind of irrigation system	do not water	5	7
	hose and sprinkler	69	80
	automatic system	26	13
20. HIGHPERD: periods of highest water bills	Jan - March	3	7
	April - June	19	8
	July - Sept	48	59
	Aug - Dec	0	3
	always same	19	21
	do not know	10	4

Table 11.--Conservation attitude data

Question	Response category	Percentage in response category Orlando	St. Petersburg
1. BELWSHRT: belief in a water shortage	yes	29	33
	no	71	67
2. PROBYR: year by which a water shortage will continue or develop	1981	2	6
	1985	42	45
	2000 or beyond	39	28
	never	18	20
3. DEGSEV: degree of severity of present water shortage	very serious	3	4
	fairly serious	19	14
	not serious	3	5
	do not know	5	15
	no shortage exists	69	61
Causes of present of future water shortage:			
4. LARDRY: lakes, rivers drying up	great extent	32	11
	some extent	40	46
	not at all	26	34
	no answer/ do not know	2	8

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	St. Petersburg
5. LACKRAIN: lack of rainfall	great extent	36	31
	some extent	38	40
	not at all	26	22
	no answer/ do not know	2	7
6. DEPLGRW: depleting groundwater	great extent	34	35
	some extent	43	36
	not at all	15	17
	no answer/ do not know	7	12
7. POPGRLOC: local population growth	great extent	70	69
	some extent	28	20
	not at all	0	4
	no answer/ do not know	2	6
8.--POPGROTH: population growth in other areas	great extent	49	57
	some extent	38	30
	not at all	9	7
	no answer/ do not know	4	6

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
9. INCWATUS: increased water usage due to technical change			
	great extent	43	47
	some extent	42	37
	not at all	13	8
	no answer/ do not know	2	8
10. ICWASTE: increased water usage due to waste			
	great extent	51	47
	some extent	42	38
	not at all	6	8
	no answer/ do not know	2	7
11. COMINDUS: increased water usage due to commercial and industrial needs			
	great extent	43	29
	some extent	43	51
	not at all	6	12
	no answer/ do not know	6	7

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
12. AGRIUSE: increased water usage due to agricultural needs	great extent	19	15
	some extent	60	58
	not at all	15	18
	no answer/ do not know	5	7
13. POLLUTE: increased contamination of water supplies	great extent	49	39
	some extent	45	39
	not at all	4	15
	no answer/ do not know	2	7
14. WATUTIL: water utilities have not taken the necessary steps to provide enough water	great extent	17	25
	some extent	66	45
	not at all	13	18
	no answer/ do not know	4	12

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	St. Petersburg
Indicate which of these conservation methods you practice and to what extent:			
15. TEESHAVC: turning off the water while brushing teeth and showering			
	large effort	10	44
	medium effort	19	26
	small effort	39	14
	no effort	25	15
	does not apply	0	1
16. DISHWASC: using dishwasher only when full			
	large effort	23	15
	medium effort	2	4
	small effort	6	0
	no effort	2	3
	does not apply	68	79
17. SHOWERC: taking shorter showers			
	large effort	19	41
	medium effort	19	27
	small effort	31	11
	no effort	15	12
	does not apply	16	8

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
18. WATERLGC: cutting back on lawn watering time			
	large effort	23	16
	medium effort	16	12
	small effort	19	15
	no effort	15	5
	does not apply	27	52
19. BATHC: filling bathtub only 1/4 full			
	large effort	16	25
	medium effort	13	10
	small effort	26	9
	no effort	13	18
	does not apply	32	40
20. TOILTC: cutting back on times the toilet is flushed			
	large effort	6	19
	medium effort	21	20
	small effort	24	19
	no effort	45	39
	does not apply	3	3

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
21. CAPREUSE: recycling shower water			
	large effort	10	3
	medium effort	1	0
	small effort	8	4
	no effort	68	86
	does not apply	13	8
22. TTBRICC: placing a brick in the toilet tank			
	large effort	2	7
	medium effort	2	4
	small effort	8	4
	no effort	60	75
	does not apply	29	10
Indicate which of these water saving devices is presently installed in your home:			
23. PRESHDC: pressurized showerheads	yes	39	29
	no	61	71
24. SSWASMC: suds-saving washing maching	yes	16	12
	no	82	87

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
25. SHTRWSTC: shallow trap water saving toilet	yes	3	4
	no	97	96
26. CHEMTTC: chemical toilet	yes	2	1
	no	98	98
27. LOWVDISC: low volume dishwasher	yes	8	6
	no	90	91
	does not apply	2	3
28. DUFLTTC: dual flush toilet tank	yes	3	3
	no	97	97
29. WLESSFAC: washerless faucets	yes	42	42
	no	58	57
30. RECINCR: a recent local water price increase	yes	66	91
	no	26	5
	do not know	8	4
31. DECONO: this price increase led to a water use reduction	yes	24	37
	no	42	55
	does not apply	33	8

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
32. FUTINCR: there is an anticipated water price increase in the near future	yes	69	88
	no	26	10
	do not know	5	2
33. DECON50: you would decrease your water use if the price rose by 50%	yes	74	71
	no	26	29
34. HOWDE50: you would decrease your water use (if the price rose by 50%) by how much	1 - 10%	19	35
	11 - 20%	34	18
	21 - 30%	15	11
	over 30%	2	9
	does not apply	26	2
	do not know	3	25
35. DECON100: you would decrease your water use if the price rose by 100%	yes	89	81
	no	11	19

Table 11.--Conservation attitude data--Continued

Question	Response category	Percentage in response category: Orlando	Percentage in response category: St. Petersburg
36. HOWDE100: you would decrease your water use (if price rose by 100%) by how much			
	1 - 10%	13	30
	11 - 20%	19	12
	21 - 30%	21	18
	over 30%	34	23
	does not apply	11	18
	do not know	2	0
37. INSTWADV: you would decrease your water usage by installing water saving devices			
	yes, immediate installment	13	25
	yes when needed a new fixture only	24	33
	no	60	41
	do not know	2	1

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