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An Analysis of the Effects of Sociodemographic Factors on Daily per Capita Residential Water Use in Texas Cities

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TECHNICAL COMPLETION REPORT

AN ANALYSIS OF THE EFFECTS OF SOCIODEMOGRAPHIC FACTORS ON DAILY PER CAPITA RESIDENTIAL WATER USE IN TEXAS CITIES

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Introduction

Water is a key resource of concern to residents and decision makers in the State of Texas and in many other parts of the United States. Careful planning for its use is of utmost importance for the State and the Nation. Such planning requires careful consideration of numerous factors including hydrologic and physiographic factors, engineering feasibility and economic feasibility. At the same time, it is increasingly evident that water needs are closely tied to population growth and to the social, economic and demographic characteristics of the population (Murdock et al., 1985). Thus, attempts to plan for the use of water resources have become increasingly inclusive of socioeconomic as well as physical variables as the costs of incorrectly projecting water demand and misallocating funds for facility construction and management have become apparent (Stees et al., 1976; McFarland and Hyatt, 1973; Reid, 1971; Texas Department of Water Resources, 1984).

To date, however, water-related socioeconomic research has concentrated on:

1. water use policy and water use planning
2. the demographic and social correlates of water and other resource use
3. the effects of water use and availability on demographic and social patterns
4. methodologies for projecting demands for resources and the implications of the use of resources

An extensive body of research addresses both the need for, and the dimensions that must be considered in, water use policy formation and planning (Markusen, 1978; U.S. Water Resources Council, 1978; Council for Agriculture Science and Technology, 1982; National Water Commission, 1973;

Office of Technology Assessment, 1983; Texas Department of Water Resources, 1984). Such analyses persuasively argue for the use of comprehensive, multidisciplinary planning formats, but as several recent reviews of water resources research efforts have noted (Francis, 1982; Napier et al., 1983), much of the basic research necessary to establish the relationships that should form the bases of the information used in such planning has not been completed.

The demographic and social correlates of water use have not been sufficiently established. Although total population and demographic structure characteristics are often used in projecting demands for water resources (Mercer and Morgan, 1978; Texas Department of Water Resources, 1984), several recent efforts evaluating the use of demographic and social variables in water use planning have noted that few of the relationships between demographic and social factors and water use have been established empirically (Murdock et al., 1985; Korsching and Nowak, 1983; Francis, 1982). Thus, it is unclear what effects differences in household or family composition patterns or the age structure of a population have on usage of water and related resources. In like manner, although given some attention in the literature (Larson and Hudson, 1951; Bogue, 1963; Kubat et al., 1968; Francis, 1982; Napier et al., 1983), the relationships between such crucial social variables as socioeconomic status, ethnic status and perceptions of water conservation requirements and water use have not been adequately examined. Since other resource uses, such as energy use (Morrison, 1976), show substantial variation across demographic, social and cultural variables, similar effects are likely to be found between demographic, social and cultural variables and water use.

The effects of water use and availability on population and social patterns have been given considerable attention (Williford et al., 1976; Doeksen and Pierce, 1976; Albrecht et al., 1984; Murdock et al., 1984; Albrecht and Murdock, 1985). Such analyses suggest that changes in water resource availability or in the use of water-related forms of technology may lead to substantial changes in the population bases of areas (Albrecht and Murdock, 1985; Fitzsimmons and Salama, 1977) and may lead to related economic and community service changes (Williford et al., 1976). However, such analyses have tended to use only general and very unrefined assumptions concerning the relationships between water availability, use and technology and demographic and social factors.

An extensive body of research has also developed related to the modeling of economic and demographic factors associated with resource use and development (Leistritz and Murdock, 1981; Murdock and Leistritz, 1980; Ford, 1976; Stenehjem and Metzger, 1976; Dunn and Larson, 1963; Mercer and Morgan, 1978). Although such models have become increasingly complex, several recent reviews of these models suggest that validation of the parameter assumptions underlying them is needed (Leistritz and Murdock, 1981; Markusen, 1978). In particular, most such models project water demand and use on the basis of per capita or per population unit factors. Population composition is not taken into account.

Overall, then, although a few studies have attempted to include demographic variables--age, household size and patterns, race/ethnicity--and social, cultural and behavioral variables--such as water use preferences and cultural patterns of water use--in planning and projection efforts (Kubat et al., 1968; Dunn and Larson, 1963; Korsching and Nowak, 1983; Portney, 1982), water planning and analyses efforts have largely ignored the effects of demographic factors (other than total population size) and social factors in planning for water use and facility construction. Such neglect is particularly unfortunate in states, such as Texas, where populations display wide demographic and social diversity (Skrabanek et al., 1985) and where per capita water use varies widely from one area to another (Texas Department of Water Resources, 1984). Only if analyses of the relationships between demographic and social variables and water use and demand are completed, will it be possible to adequately employ such variables in projections of water demand. Because the inclusion of such variables in projection models should increase the accuracy of projections and improve our understanding of the numerous factors that determine patterns of water use, studies of the effects of demographic and social factors on water use and on projections of water demand deserve additional consideration.

This report presents the results of one such study sponsored by the Texas Water Resources Institute. The study has two major objectives:

1. to determine the relationships between key demographic, social and cultural variables and water use in Texas

2. to analyze the implications of the relationships between demographic, social and cultural variables and water use and demand for projections of water use and demand in Texas

Specifically, this report presents the results of an analysis of secondary and primary data in which the relationships between water use and other sociodemographic variables are examined, and it reports the effects of using sociodemographic characteristics to project water use. These relationships are of intrinsic interest to professionals involved in water planning and policy formulation, and the results will hopefully be of utility to a wide range of policy and decision makers.

The report is organized into five sections. Section I describes the data and methodologies employed in the analysis. Section II presents and discusses the results of the secondary analysis. Section III examines the results of our analysis of survey data from over 800 respondents from 8 communities selected from across the State of Texas. Section IV describes the implications of using demographic and social factors in projecting water use. The final section, Section V, presents generalizations regarding the overall effects of demographic and social factors on water use and demand and presents our preliminary recommendations regarding the use of such variables in formulating water use and demand projections. Throughout the report, it should be recognized that the fact that the study is limited to one period of time and to only selected areas of the State, clearly limits the ability to formulate generalizations that have state-wide applicability. The fact that the study is limited in several regards must be recognized.

Section I

Data and Methods

The analysis involved the use of several data sources--both secondary and primary--all of which were specifically developed for use in the project. One of these data sets consisted of secondary data on per capita residential water use (the dependent variable in the analysis) provided by the Texas Water Development Board and demographic and social data from the U.S. Bureau of the Census for 1980 (as the independent variables in the analysis).

Dependent Variables for the Secondary Analysis

Because census data on population characteristics were available only for 1980, an attempt was made to use water use data that were also applicable to the census year of 1980. Personnel from the Texas Water Development Board provided data on residential monthly water use for 677 Texas cities for each month of each year from 1964 through 1983. Because of cross-area selling of water and the combined reporting of residential and commercial water use for some cities, the adjustment of water use data to adequately reflect city-specific residential water use required an extensive effort. Such adjustments were made by staff from the Texas Water Development Board using historical data on water supply and use. An examination of these data also indicated relatively wide variation in month-to-month usage even for the same months in subsequent years. To control for such variations a standard demographic averaging technique was employed (Shryock and Siegel, 1980). This consisted of the averaging of data for a three-year period centered on the census year (i.e., for 1979, 1980 and 1981) for the selected months. In order to provide an indication of water usage during both peak use periods and periods for which usage was likely to be limited largely to in-home water use, three month averages of use for one summer period (June, July and August) and one winter period (December, January and February) were computed. Thus, the water use variable was based on three-year averages of three-month periods for a summer (i.e., June, July, and August of 1979, 1980 and 1981) and a winter period (i.e., December, January, and February 1979, 1980, and 1981). All water use figures were converted to per capita per day use figures by simply dividing each city's total water use for the period by the 1980 Census population for the city and the number of days in the three months.

Independent and Control Variables for the Secondary Analysis

A variety of independent and control variables were used in the secondary data analysis. Table 1 presents a list of the independent variables initially selected for consideration for use in the analysis. As the data in this table indicate, a wide variety of factors representing three broad categories of variables--demographic, economic, and housing--were utilized. These three categories of variables were employed because demographic variables are one major emphasis of the study; economic variables have been widely shown to affect resource use and thus were clearly relevant; housing variables were included because it is apparent that the size, type and housing conditions of persons would affect their use of water.

Correlations between the 57 variables were run to assess the extent of multicollinearity. For sets of variables correlated at 0.6 or above, one variable in each set was selected for further analysis. Such selections were made on theoretical and other grounds, but in several cases, the choice of which variable should be retained was admittedly somewhat arbitrary. For example, population size in 1980 and total housing units

Table 1

List of Independent Variables Considered for Use in Secondary Data Analysis by Category and Acronym

DEMOGRAPHIC

*PCTURB	- Percent urban
POP80	- Population 1980
FAM80	- No. of families 1980
HH80	- No. of households 1980
AVGSIZHH	- Average size of household (persons/no. of households)
*+MEDAGE	- Median age
AGEUND18	- Percent pop. under age 18
AGE65	- Percent pop. over age 65
*+†PCTBLK	- Percent black
*+†PCTSPAN	- Percent Spanish origin
*+PCTMARR	- Percent married
*+†PCTFLYH	- Percent of persons in family households
PCTGQ	- Percent of persons in group quarters
PCTONEP	- Percent of households = one-person households
*+PCTMAH	- Percent of households = married couple family household
PCTENROL	- Percent enrolled in school
PCTBLHS	- Percent of 25 yrs. and over not completed high school
PCTABHS	- Percent of 25 yrs. and over completed high school
CHG	- Numerical change in population, 1970-80

ECONOMIC

*+†PCTUNEMP	- Percent of civilian labor force unemployed
MEDINC	- Median income
*+PERCAPT	- Total per capita income
PCTBPOV	- Percent below poverty

Percent of employed persons 16 yrs and over by industry:

*+†PCTAGFF	- Agriculture, forestry, fisheries, and mining
*†PCTCONS	- Construction
*PCTMANF	- Manufacturing (nondurable & durable)
*PCTTRANS	- Transportation
*†PCTCOMM	- Communication and other public utilities
*†PCTWHOLE	- Wholesale trade
*PCTRETAL	- Retail trade
PCTFIRE	- Finance, insurance, and real estate
*PCTBUSIN	- Business and repair services
*+†PCTPRS	- Personal entertainment and recreation services
*†PCTPROF	- Professional and related services
*†PCTADMIN	- Public administration

Table 1 (continued)

Percent of employed persons 16 yrs and over by occupation:

PCTMANGR	- Managerial and professional specialty
*+PCTTECHN	- Technical sales and administration support
*PCTSERVC	- Service
PCTFFF	- Farming, forestry, and fishing
*+†PCTPROD	- Precision production, craft, and repair
*†PCTOPFL	- Operators, fabricators, and laborers

HOUSING

CHGHS	- Numerical change in housing, 1970-80
MEDPERHU	- Median persons per occupied housing unit
PERHUNIT	- Persons per occupied housing unit
MEDVALUE	- Median value of specified owner-occupied, noncondominium housing unit
*MEDROOM	- Median rooms per total year-round housing unit
MEDCRENT	- Median contract rent for specified renter-occupied housing unit paying cash rent
*+†TOTYRNHS	- Total year-round housing units
OCCURNHS	- Occupied year-round housing units
*PCTOCCUP	- Percent year-round housing units
*PCTMOBIL	- Percent mobile home or trailer
*†PCT1UNIT	- Percent of year-round housing units - 1 unit at address
PCTMULT	- Percent of year-round housing units - 2 or more units at address
*PCTOTPL	- Percent of year-round housing units with complete plumbing for exclusive use
*+PUBWATER	- Percent of year-round housing units with water source = public system or private company
*+†YRAB70	- Percent of year-round housing units built after 1970
YRBL70	- Percent of year-round housing units built before 1970

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* Indicates variables selected after data were analyzed for potential problems of multicolliniarity.

+ Indicates variables used in the most parsimonious winter models.

† Indicates variables used in the most parsimonious summer models.

were correlated at a level of 0.99. However, since the number of housing units can be seen as reflecting water-using entities (and water-reporting entities), it, rather than population, was used in the analysis. As a result of such procedures, of the initial list of 57 variables, 32 variables were selected for further analysis. These 32 are indicated by asterisks in Table 1. Finally, in the course of the analysis described below, it was shown that a subset of variables most parsimoniously predicted per capita water use for each of the two (winter and summer) periods. These variables are noted in Table 1 (see notes in Table).

In the analysis of the relationships between per capita water use and the independent variables, it was also deemed necessary to control for variables that might lead to spurious relationships between water use and the independent variables (in other words, variables that could be the cause of the relationships but which, if omitted, might either increase or decrease the level of relationship found between the dependent variable and the independent variables). The control variables considered for inclusion were:

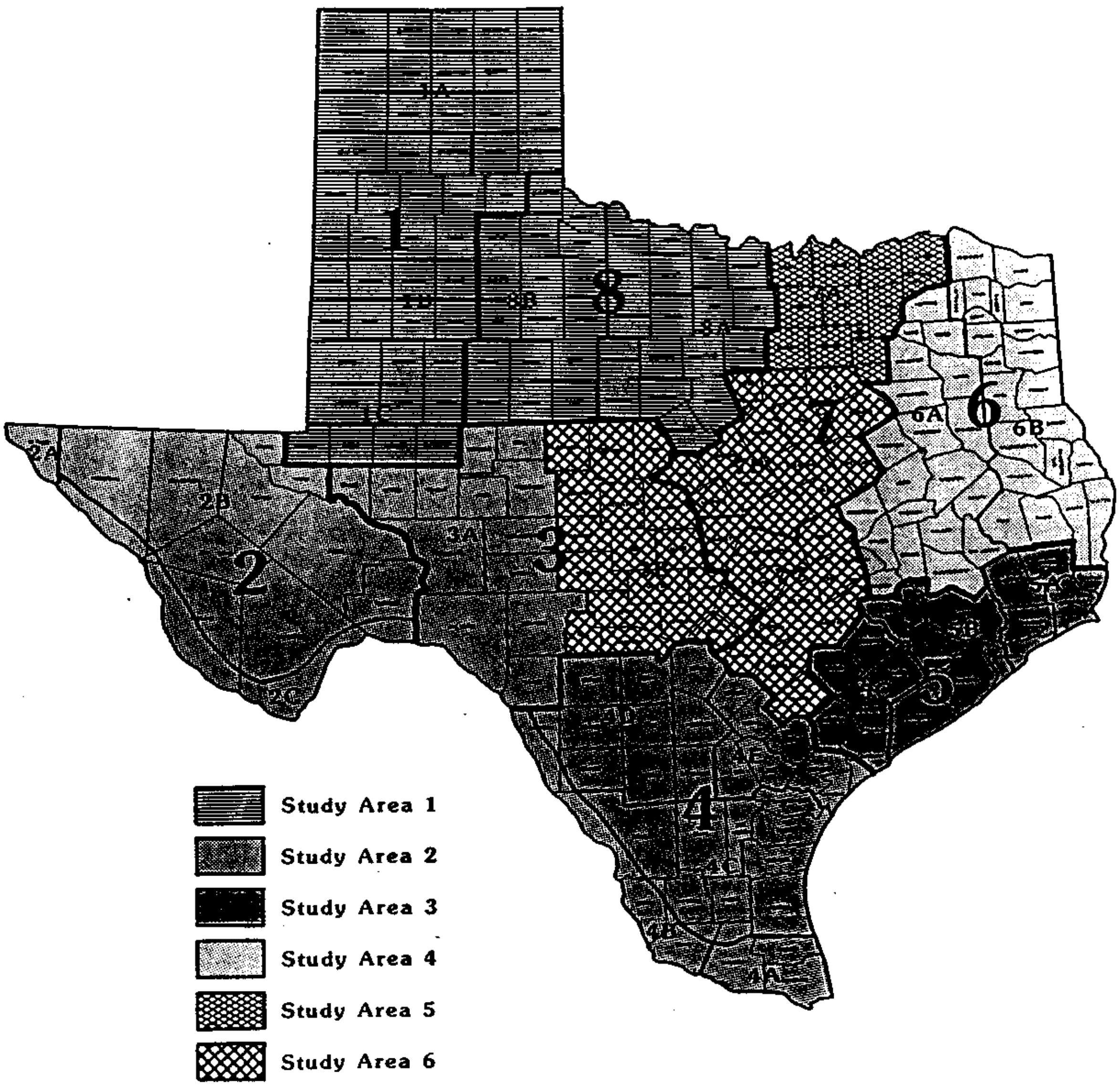
1. population size of the city
2. population growth rate of the city from 1970-80
3. region of the State
4. water quality as measured by total dissolved solids
5. quality of the water system
6. water costs
7. soil type

The rationales for the use of these variables were that the size and rate of growth in the city might result in the use of procedures that would either enhance or reduce the level of efficiency of use of water resources.

Texas shows extreme regional diversity with some areas of the Eastern part of the State having nearly 60 inches of annual rainfall while areas in West Texas have less than 10 inches. Thus, it was deemed essential to control for each city's regional location. Land-resource regions were considered, but because of limitations in the number of observations relative to the number of regions, these regions were further combined into six regions that were used in the analysis. The areal delineations of the original regions and those used in our analysis are indicated in Figure 1.

Water quality is an extremely difficult variable to measure and no widely agreed upon measure exists. However, in an attempt to measure the effects of this variable on water use, the variable of total dissolved solids for each water system was obtained from the Texas Department of Health and used in the analysis.

Data on the final three control variables proved to be impossible to obtain in a uniform and sufficiently cost-effective manner. Although it had initially been thought that water systems were rated (approved) by the Texas Department of Health, further research indicated that all water systems in Texas must meet minimum health standards in order to operate and no other generally applicable measure of system quality could be obtained. In like manner, data on water costs could not be obtained without contacting each jurisdiction, a task beyond the available resources for the project, and data on soil types was such that it was impossible to adequately characterize each city's soil type without using either such broad categories that they were largely coterminous with regional differences (already included) or too specific to allow for a simple classification for each city.



The numbered areas on this map refer to land-resource divisions (Texas Water Development Board, 1960).

Figure 1

Study Area Regions as Derived from Land-Resource Divisions

Thus, analysis involving control variables was limited to consideration of population size, population growth rates, regional location, and total dissolved solids. Of these initial control variables selected for examination, preliminary analysis clearly showed population growth rates and total dissolved solids to be largely unrelated to per capita water use levels. They were thus eliminated from further evaluation. Population size and region were found to have effects, however, and throughout the analysis presented below, regressions within categories of these two control variables are examined to discern their potential effects on water use.

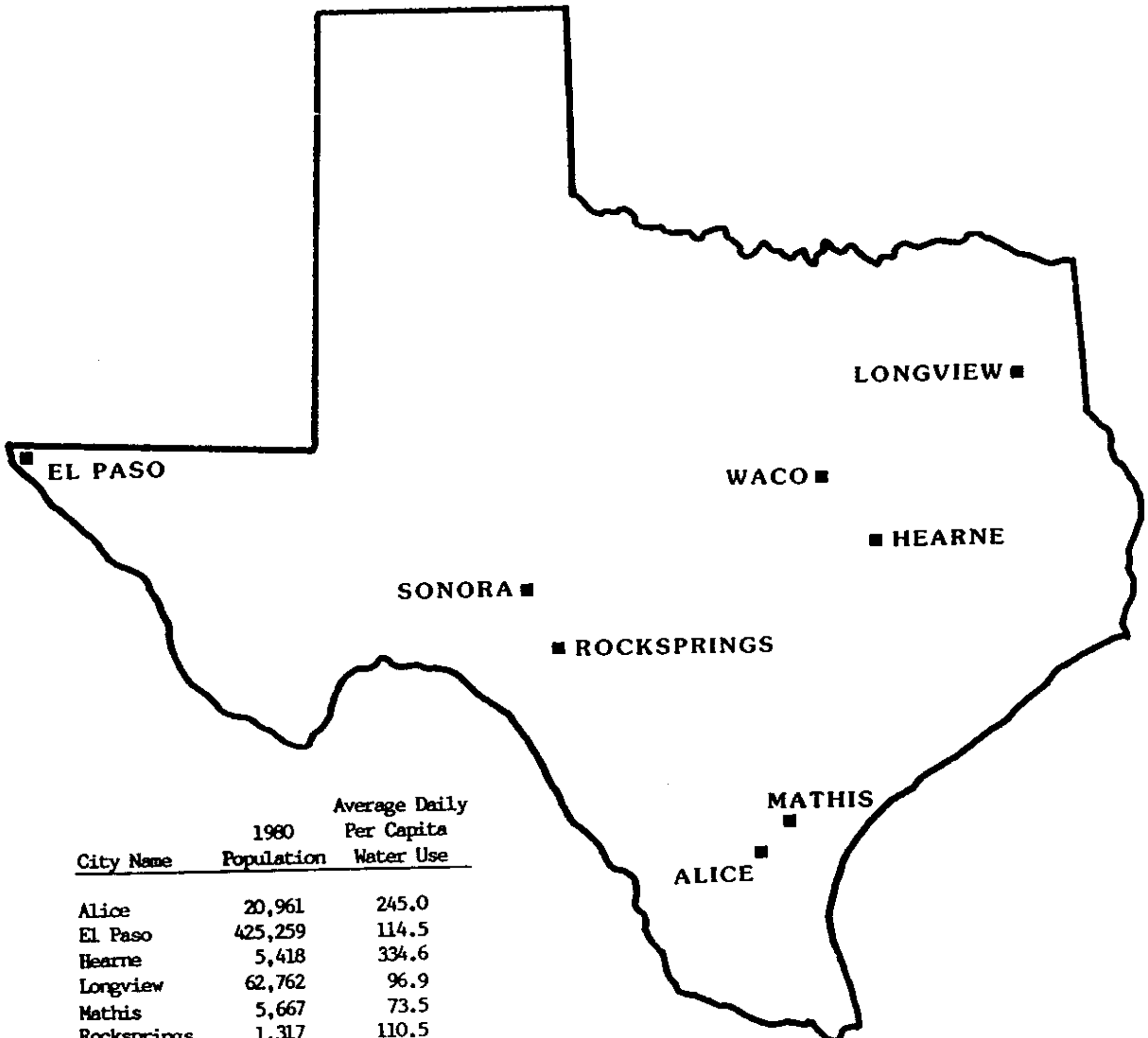
The major forms of statistical analysis used in the secondary data analysis were weighted ordinary least squares and weighted stepwise regression procedures. Stepwise procedures were utilized in order to develop the most parsimonious model, while ordinary least squares regression was used to assess overall relationships considering all variables. Weighted procedures are used because of wide differentials in the population size of the cities of interest. This procedure weights results in accordance with the population size of the city, thus properly weighting error values in terms of each city's size. Unless weighting procedures are used, variable values for all areas regardless of size (and thus their water consumption) influence the results in an equivalent manner. By giving proportionally smaller weights to places with larger populations, weighted regression provides results that more accurately reflect one's ability to predict the phenomena of interest (Gujarati, 1978; Kleinbaum and Kupper, 1978; Heaton et al., 1981).

As shall be discussed in the next section, several regression models were examined. These included total models including all 32 variables, separate models for each of the variable types (economic, demographic and housing), separate models for each region, and separate models for areas of different population size. Such models were examined for each of the winter and summer per capita use rates. The evaluation of the effects of variables on per capita water use was made by comparing the results of the different models.

Primary Data Analysis

In addition to the analysis of secondary data, an attempt was made to analyze socioeconomic and demographic variables as well as several cultural, attitudinal, and behavioral variables that might affect levels of water use at the individual level. This was done by completing telephone surveys of 814 respondents from 8 communities selected to be representative of different regions of the State, different city sizes and different levels of per capita water use. Figure 2 presents a map of the location of the cities selected and shows the 1980 population and per capita water use rates for each city. Once selected, the names of these places were sent to personnel from the Texas Water Development Board to assess whether the cities chosen had any characteristics (such as a type of water system or water purchasing arrangement) that would make them inappropriate for inclusion in the study.

After this initial review indicated that these cities were appropriate for the study, a random sample of 100 households was selected from telephone directories and adult representatives of each household (persons 18 years of age or older) interviewed by telephone during April and May of 1986. The interview took approximately 15 minutes to complete, and because of a low refusal rate (less than 10%), the sample required little replacement. The number of persons interviewed in each city allowed us to



City Name	1980 Population	Average Daily Per Capita Water Use
Alice	20,961	245.0
El Paso	425,259	114.5
Hearne	5,418	334.6
Longview	62,762	96.9
Mathis	5,667	73.5
Rocksprings	1,317	110.5
Sonora	3,856	199.7
Waco	101,261	199.3

Figure 2

Cities Included in the Telephone Survey

have a 95 percent level of confidence that the sample answers would be within 10 percent of the answers for the populations in these cities. The interview included questions about respondents' attitudes towards water use and conservation, their water costs, their type and size of housing unit, their use of water for bathing, washing clothes, washing dishes, toiletry, in hot tubs and swimming pools, for lawn watering and care, for gardening, and for vehicle maintenance. It also included standard questions on the demographic characteristics of respondents and respondents' households. The appendix provides a copy of the questionnaire used in the study.

For the primary data analysis, the major dependent variable of interest was also daily per capita water use. However, data on this variable was very difficult to obtain. Respondents were asked to provide information on monthly household water use from either a review of a recent utility bill (see question 7) or to estimate their household water use for the past month from memory (question 10). Only 223 respondents were able to locate a recent utility bill from which such information could be obtained and only 134 more were able to provide knowledgeable estimates of their water use during the preceding month. Thus, the desired dependent variable could only be obtained from less than half (357) of the 814 respondents.

As a result of this difficulty, three alternative estimates of daily per capita water use were employed in different parts of the original analysis of the primary data. These included one estimate obtained from combining respondents' answers to questions 7 and 10, thus obtaining estimates for 357 respondents; one estimate using only those 223 respondents who answered question 7 (and thus only those that had a verification of their water use); and a third estimate derived by applying a set of water-using standards to the characteristics of respondents' households. This procedure, described in greater detail in Section III of the report, involved using respondent household characteristics and use and ownership of various appliances and performance of various water-using behaviors (questionnaire items 18-28) and standard water use rates for these appliances and behaviors to estimate water use. Because this latter procedure allowed for the acquisition of uniformly determined water use data for all respondents, and results from its analysis differed little from those for the other two measures (see results in Section III), this third measure is used as the primary dependent variable in the primary data analysis.

The results of the primary data part of the study were analyzed using standard parametric (regression) and nonparametric (chi-square) statistical techniques. The results of this analysis are shown in Section III of the report. Because of the large number of potential independent variables that could be derived from the questionnaire, results are presented only for those variables seen as being most indicative of key demographic and social parameters likely to affect water use. As in the secondary data analysis, the use of regression analysis for the primary data analysis was preceded by an analysis of the variables for multicollinearity. This analysis indicated that no multicollinearity existed (that is, no variables were correlated at 0.6 or higher).

One of the major concerns with the results obtained from the primary analysis was that the responses of surveyed individuals (contacted by telephone) regarding their consumption of water might not have been accurate. Consequently, the water use records on the actual amount of metered water used by those randomly selected individuals who participated in the 1986 survey were obtained from utility companies. Project researchers obtained the names, addresses, and telephone numbers of all survey participants in each of the eight surveyed cities. A letter was then sent to the major or city manager of each city, asking them for their assistance in obtaining water use data for these individuals for the time period coinciding with the original survey dates. In three of the eight cities, utility company employees gathered the needed water use data and mailed it to us. For the other five cities, a project researcher traveled to the city and personally obtained the water use data for each household that participated in the study by going through water use and billing records.

After the water use data had been obtained, it was entered into the computer along with other survey data for each survey participant. Regression procedures were again used to determine how social and demographic variables were related to per capita water use, this time using the actual amount of water used (as obtained from the utility companies) instead of the reported water use (from the survey). A comparison of the regression results with the two different dependent variables revealed results that were virtually identical to those reported in Section III. Because of this, tables showing the results of the regression analysis on actual water use are not presented in this report (they may be requested from the authors). The actual water use data were used in the projection analysis reported in Section IV.

The results of the analysis described above are presented in the sections which follow. Although we believe that the analysis is relatively complete, it is admittedly lacking in several regards: it presents cross-sectional rather than longitudinal data and data for only a single time period; it presents data for only a limited number of areas for both the secondary and primary data analyses and examines only some of the many relevant variables that might be examined. As such, the results described and the generalizations delineated below should be used with caution.

Section II

Results of Secondary Data Analysis

In this section of the report, the results of the analysis of the secondary data collected from the Texas Water Development Board and the U.S. Bureau of the Census are reported. This analysis consisted of regression analysis of indicators of demographic, economic and housing factors on average daily per capita water use in 1980 for 677 cities in Texas. Both ordinary least squares regression and stepwise regression were used in this analysis. The stepwise procedure used was the Statistical Analysis System (SAS) procedure STEPWISE with a minimum level of .15 for selection (SAS, 1985). In using a stepwise procedure it must be recognized that such models are sensitive to the initial list of variables included in the stepwise and to the initial variables selected. The use of alternative variable sets could produce quite different results (Kerlinger and Pedhazur, 1973). Dependent variables representing average daily per capita usage for three winter months--December, January, and February--as well as rates representing a summer period--June, July and August--are used in the analysis.

The results of this analysis are presented in 26 tables, 13 for the winter use rates and 13 for the summer per capita use rates. In each table, 5 columns of information are presented. These include (in columns 1 and 2) the unstandarized regression coefficients together with an indication (an asterisk) of the statistical significance of the relationships between the independent variable and average daily per capita use rates and standardized coefficients indicating the relative importance of each of the independent variables in explaining the dependent variable. Also shown at the bottom of column 1 is the multiple coefficient of determination, indicating the percent of the variation in the dependent variable explained by the independent variables in the model.

Columns 3 through 5 show the results of the stepwise regression analysis of each model. Column 3 shows the order of entrance of the variables into the stepwise procedure using a significance level of 0.15. Column 4 shows the unstandarized coefficient from the stepwise regression and presents an indicator (an asterisk) indicating whether or not the relationships involving the variable are significantly related to per capita water use. The final column shows the cumulative percent of variation explained (the cumulative R^2) for the variables as they entered into the stepwise model. Thus, by tracing the order of entrance (from column 3) with the cumulative percent of variation explained (in column 5), one can obtain an overall picture of the predictive ability of a parsimonious model involving the general variables of interest.

The 13 tables for each of the two dependent variables (per capita water use in the winter and summer months) include one model showing the overall relationship of all 32 variables (derived by analyzing correlations between the original 57 variables) to average daily per capita water use. Tables 2-4 of each set present the results of regression within the 3 general variable categories of demographic, economic and housing variables. Tables 5-13 in each set present results controlling for values of 2 variables that seem likely to affect the nature of the relationships between the independent and dependent variables. These variables are population size in 1980 (3 categories, less than 2,500, 2,500-10,000 and more than 10,000) and region of the State (6 regions are used, see Figure 1). Additional control variables originally considered for inclusion-- population growth rate and total dissolved solids were analyzed in separate regressions; they were found not to be significantly related to the dependent variable (as indicated by ordinary least squares regression analysis) and were found not to enter into any of the relevant models using stepwise procedures. Further analysis of the possible effects of these variables was thus deemed to be unnecessary. For the two control variables that are included (population size and region of the State), the categories used are admittedly somewhat arbitrarily drawn (but within land-resource divisions) to obtain similar numbers of cities in each group. Despite such limitations, we believe the use of these variables provides valuable insights concerning the effects of two key variables on per capita water use.

Results for Winter Months (December, January and February)

Tables 2-14 present results for ordinary least squares and stepwise regression analysis on average daily per capita water use for the months of December, January and February of three years, 1979, 1980 and 1981. This period of use is one in which winter conditions prevail across the State and thus climatic differences can be expected to play a minimal role.

Table 2 presents the results of the total model for the winter average daily per capita water use factor. An analysis of the data in this Table shows that median age, the percent of the population that is Black and the percent that is Hispanic, per capita income, the percent of employment in recreational services, the total number of year-round housing units, and the percent of the population using a public water system are directly and significantly related to daily per capita rates of water use. On the other hand, inverse and significant relationships are found between the percent of the population that is married, the percent of persons in family households, and the percent of housing units in the city built after 1970

Table 2

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January, and February, 1980 on Selected Socioeconomic Variables for 1980 for Texas Cities
(N = 677)

Variable Name	Ordinary Least Squares: Unstandardized Coefficient	Ordinary Least Squares: Standardized Coefficient	Stepwise Regression: Order of Entrance	Stepwise Regression: Unstandardized Coefficient	Stepwise Regression: R^2
Intercept	48.42	0.00	--	---	---
PCTURB	-0.04	-0.45	--	---	---
MEDAGE	1.58*	0.16	14	1.31*	0.54
PCTBLK	0.45*	0.16	19	0.37*	0.55
PCTSPAN	0.64*	0.43	11	0.62*	0.54
PCTMARR	-2.18*	-0.31	2	-1.64*	0.43
PCTFLYH	-0.94*	-0.21	12	-1.67*	0.54
PCTMAH	0.66	0.19	17	0.61*	0.55
PCTUNEMP	-0.33	-0.06	20	-0.53	0.55
PERCAPT	0.001*	0.24	10	0.001*	0.53
PCTAGFF	1.62	0.25	6	0.44	0.51
PCTCONS	1.56	0.12	9	Eliminated: Step 16	0.52
PCTMANF	1.50	0.29	--	---	---
PCTTRANS	1.32	0.07	--	---	---
PCTCOMM	2.32	0.07	--	---	---
PCTWHOLE	0.12	0.01	--	---	---
PCTRETAL	1.04	0.08	--	---	---
PCTBUSIN	2.60	0.10	--	---	---
PCTPRS	5.17*	0.16	8	3.24*	0.52
PCTPROF	1.05	0.16	--	---	---
PCTADMIN	1.02	0.09	--	---	---
PCTTECHN	1.03	-0.14	18	0.86*	0.55
PCTSERVC	-0.76	0.07	--	---	---
PCTPROD	0.49	0.55	15	1.25*	0.55
PCTOPFL	-0.73	-0.10	5	Eliminated: Step 13	0.50
MEDROOM	-9.15	-0.08	--	---	---
TOTYRNHS	0.001*	0.31	1	0.001*	0.38
PCTOCCUP	-2.23	-0.18	4	-2.42	0.48
PCTMOBIL	0.67	0.07	--	---	---
PCT1UNIT	0.28	0.08	--	---	---
PCTTOTPL	1.17	0.07	--	---	---
PUBWATER	1.06*	0.08	7	0.93*	0.52
YRAB70	-0.47*	-0.18	3	-0.35*	0.46

Adjusted R^2 = 0.54

*Indicates relationship is significant at the .05 level.

and per capita water use. These results suggest that older cities with larger minority populations, cities specializing in recreation and entertainment and those that have a majority of their populations using public water systems are likely to consume more water than cities with a large percentage of relatively new housing and family households. It thus suggests that socioeconomic variables such as the age and minority status of a population as well as the characteristics of its households and housing stocks can be important predictors of per capita water use. Thus over 54 percent of the variation in per capita water use was explained by the variables in the model. An examination of the standardized regression coefficients (the beta coefficients), also shows that demographic variables such as the percent of the population that is Spanish, employment in skilled occupations (precision production, craft and repair), the number of total year-round housing units, and similar factors are the most important variables in the model.

The results of the stepwise analysis of the total model are shown in columns 3-5. An analysis of these results clearly shows that the total number of year-round housing units, the percent of the population that is married, and the percent of year-round housing units built after 1970 are key variables explaining 46 percent of the total variation (55 percent) explained by the stepwise procedure.

Overall, then, the results in Table 2 strongly suggest that several characteristics of cities are important in explaining per capita water use. Thus, they tend to provide general support for this study's major premise that attempts should be made to take sociodemographic variables into account when projecting water use.

Tables 3 through 5 present results for the 32 variables (shown in the overall model) divided into 3 mutually exclusive categories: demographic, economic and housing variables. The results in these tables generally reinforce the results discussed in relation to the overall model, pointing to demographic and housing factors as being the most important for explaining water use with each set explaining roughly 48 percent of the variation in water use. As shown in Table 3, of the 10 demographic variables in the model, 8 are significantly related to water use with population size being the single most important variable followed by the percent of the population that is Spanish, the percent of persons in married couple households, and the percent of adults that are married.

The economic model (see Table 4) is less adequate in predicting water use, explaining only 33 percent of the variation. In this model, income, unemployment, and employment in business and in production crafts were significantly related to per capita water use.

In the housing model (Table 5), the total number of housing units, the size of the units (in rooms), the percent of the units built since 1970, and the median value of housing units are the key predictors of per capita water use. The data in the housing model thus clearly point to cities with newer housing stocks as having lower levels of per capita water use.

Tables 6-8 present models in which cases have been stratified by the population size of the city in 1980. Three models are shown, one for places of 2,500 or less population, one for places with populations between 2,500 and 10,000 and one for places with more than 10,000 population. In these models the variables considered are those that the stepwise regression of the total 32-variable model indicated were predictive of per capita water use. Thus, 16 variables derived from the total 32 variable

Table 3

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Demographic Variables for 1980 for Texas Cities
(N = 677)

Variable Name	Ordinary Least Squares: Unstandardized Coefficient	Standardized Coefficient	Stepwise Regression: Order of Entrance	Unstandardized Coefficient	R^2
Intercept	151.10	0.00	--	---	---
POP80	0.001*	0.45	1	0.001*	0.38
PCTURB	-0.06	-0.07	--	---	---
AVGSIZHH	6.86*	0.19	--	---	---
MEDAGE	0.72	0.07	3	1.54*	0.45
PCTBLK	0.53*	0.18	7	0.38*	0.48
PCTSPAN	0.65*	0.44	4	0.44*	0.46
PCTMARR	2.44*	0.35	2	Eliminated: Step 6	0.43
PCTFLYH	-0.96*	-0.22	5	-1.16*	0.47
PCTMAH	-1.31*	-0.37	--	---	---
PCTBLHS	-0.33*	-0.11	--	---	---

Adjusted R^2 = 0.48

*Indicates relationship is significant at the .05 level.

Table 4

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Economic Variables for 1980 for Texas Cities
(N = 677)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	18.28	0.00	--	---	---
PCTUNEMP	0.84*	0.14	4	0.094*	0.26
PERCAPT	0.001*	0.18	9	0.00*	0.33
PCTAGFF	0.23	0.04	7	Eliminated: Step 15	0.32
PCTCONS	2.15	0.17	12	2.22*	0.34
PCTMANF	-1.35	-0.26	5	-1.23*	0.29
PCTTRANS	-0.49	-0.27	10	Eliminated: Step 13	0.33
PCTCOMM	-0.21	-0.01	--	---	---
PCTWHOLE	-0.97	-0.05	--	---	---
PCTRETAL	-2.08	-0.16	3	-1.74*	0.23
PCTBUSIN	7.70*	0.30	2	8.20*	0.21
PCTPRS	8.47*	0.27	1	8.88*	0.11
PCTPROF	0.61	0.09	14	0.76*	0.35
PCTADMIN	-1.52	-0.13	6	-1.29*	0.31
PCTTECHN	1.14	0.15	--	---	---
PCTSERVC	0.59	0.05	--	---	---
PCTPROD	-1.62*	-0.18	11	-1.69*	0.34
PCTOPFL	2.26*	0.30	8	1.75*	0.32

Adjusted R^2 = 0.33

*Indicates relationship is significant at the .05 level.

Table 5

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Housing Variables for 1980 for Texas Cities
(N = 677)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	304.66	0.00	---	---	---
MEDPERHU	5.34	0.06	7	7.14*	0.49
MEDVALUE	0.001*	0.18	4	0.001*	0.47
MEDROOM	-20.93*	-0.19	2	-25.60*	0.43
TOTYRNHS	0.001*	0.47	1	0.001*	0.38
PCTOCCUP	-1.21*	-0.10	6	-1.28*	0.48
PCTMOBIL	-0.05	-0.00	---	---	---
PCT1UNIT	-0.16	-0.05	---	---	---
PCTTOTPL	-0.67	-0.04	---	---	---
PUBWATER	1.15*	0.09	5	1.17*	0.48
YRAB70	-0.73*	-0.29	3	-0.73*	0.45

Adjusted R^2 = 0.48

*Indicates relationship is significant at the .05 level.

model are examined in each of the 3 population-size models. The purpose of these 3 models is to identify the extent to which population size effects the relationships between socioeconomic factors and per capita water use.

The data in Tables 6-8 show population size to have a substantial effect on water use. The variables explained over 62 percent of the variation in per capita water use for places over 10,000 population while less than 23 percent of the variation is explained for the two categories of smaller places. In addition, the data in these tables indicate some inconsistencies in the nature of the relationships between different variables and per capita water use in different size-of-place categories. For example, median age is inversely related to water use in places with less than 2,500 population but directly related to water use in both categories of larger places. For other variables, however, consistency across categories is evident. The percent of year-round housing units is significant and inversely related to water use in all categories of places. It is also evident that the relative importance of the different types of variables varies by population size, with demographic variables and housing variables being the most important predictors in the model for places over 10,000 population while economic variables are more important for the models in smaller places. When taken together, the results in Tables 6-8 suggest that the standard socioeconomic variables included in this analysis are better predictors of water use in large than in small places. This further suggests that the use of such factors in projections is likely to be particularly important in larger cities but that additional factors, not specified in the models presented here, are affecting water use in small towns and cities in Texas. In sum, it appears that, using the variables included in this analysis, one is likely to be able to project water use

Table 6

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities with Less than 2,500 Population in 1980
(N = 268)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	351.31*	0.00	--	---	---
MEDAGE	-0.09	-0.01	--	---	---
PCTBLK	-0.03	-0.01	--	---	---
PCTSPAN	0.49*	0.26	--	---	---
PCTMARR	-1.85	-0.20	5	-2.82*	0.21
PCTFLYH	-1.75	-0.20	--	---	---
PCTMAH	-0.07	-0.01	--	---	---
PCTUNEMP	0.59	0.06	--	---	---
PERCAPT	0.01*	0.38	4	0.01*	0.16
PCTAGFF	0.84*	0.18	3	1.20*	0.14
PCTPRS	0.84	0.03	--	---	---
PCTTECHN	1.89*	0.23	6	1.16*	0.22
PCTPROD	1.19*	0.15	--	---	---
TOTYRNHS	0.02	0.10	2	0.03*	0.12
PCTOCCUP	-2.09*	-0.27	1	-2.33*	0.09
PUBWATER	0.56	0.09	7	0.65*	0.23
YRAB70	-0.20	-0.07	--	---	---

Adjusted R^2 = 0.22

*Indicates relationship is significant at the .05 level.

Table 7

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities with 2,500 to 10,000 Population in 1980
(N = 258)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	295.73*	0.00	--	---	---
MEDAGE	0.49	0.06	--	---	---
PCTBLK	-0.08	-0.02	--	---	---
PCTSPAN	-0.02	-0.01	--	---	---
PCTMARR	-3.30	-0.40	4	-2.59*	0.20
PCTFLYH	-0.30	-0.05	--	---	---
PCTMAH	0.39	0.09	--	---	---
PCTUNEMP	0.43	0.06	--	---	---
PERCAPT	0.001*	0.33	3	0.004*	0.14
PCTAGFF	1.15*	0.23	5	1.13*	0.23
PCTPRS	4.78*	0.20	2	4.45*	0.12
PCTTECHN	1.56*	0.23	7	1.39*	0.25
PCTPROD	0.95	0.12	--	---	---
TOTYRNHS	0.00	0.01	--	---	---
PCTOCCUP	-2.63*	-0.22	1	-2.58*	0.07
PUBWATER	1.03*	0.11	6	0.78	0.25
YRAB70	-0.38	-0.17	8	0.37*	0.28

Adjusted R^2 = 0.23

*Indicates relationship is significant at the .05 level.

Table 8

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities with >10,000 Population in 1980
(N = 149)

Variable Name	Ordinary Least Squares: Unstandardized Coefficient	Ordinary Least Squares: Standardized Coefficient	Stepwise Regression: Order of Entrance	Stepwise Regression: Unstandardized Coefficient	R^2
Intercept	300.91	0.00	--	---	---
MEDAGE	3.66*	0.25	5	3.01*	0.61
PCTBLK	0.53	0.20	--	---	---
PCTSPAN	0.89*	0.63	7	0.68*	0.63
PCTMARR	-1.59	-0.23	2	Eliminated: Step 9	0.54
PCTFLYH	-2.08*	-0.52	8	-1.45*	0.64
PCTMAH	1.18	0.35	--	---	---
PCTUNEMP	-1.26	-0.23	--	---	---
PERCAPT	0.00	0.19	10	0.00	0.64
PCTAGFF	0.46	0.05	4	0.69	0.59
PCTPRS	1.95	0.06	--	---	---
PCTTECHN	0.65	0.07	--	---	---
PCTPROD	1.35	0.14	--	---	---
TOTYRNHS	0.00*	0.39	1	-0.001*	0.48
PCTOCCUP	-3.15*	-0.24	6	-2.20*	0.62
PUBWATER	1.25	0.06	--	---	---
YRAB70	-0.29	-0.11	3	-0.30	0.57

Adjusted R^2 = 0.62

*Indicates relationship is significant at the .05 level.

more accurately in larger than in smaller population areas and that the use of the variables described here are likely to increase one's ability to predict water use more in larger than in smaller population areas.

Tables 9-14 present results of models in which places were stratified by their location in different regions of the State. The six regions (study areas) included are delineated in Figure 1. An examination of the data in these tables suggests that socioeconomic variables differ in their ability to predict water use in different regions of the State. Thus, whereas the variables explain 79 percent or more of the variation in both regions 3 and 5 and 46 percent of the variation in water use in region 6, they explain less than 40 percent of the variation in water use in the remaining regions. In addition, the data in these tables suggest that there are clear differences in the types of variables that serve best to explain water use in different areas of the State. In those regions where the predictive ability of the model is most extensive (regions 3 and 5), demographic and housing variables such as the total number of year-round housing units, the percent of the population that is Hispanic, the percent of the population in family households and marital status are the best predictors of water use. The direction of the relationships between these variables and water use differ from one model to another, however, suggesting that regionally specific factors are leading to different effects in different regions of the State.

For the other regions of the State, in which a smaller percentage of the variation in water use is explained, there is substantial variability in the variables that are selected by the stepwise procedure as being the best for explaining water use. In regions 1, 2 and 6, housing and economic variables appear to be most important while in region 4, demographic,

Table 9

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 1
(N = 139)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	243.51	0.00	--	---	---
MEDAGE	-1.51	-0.26	11	Eliminated: Step 14	0.33
PCTBLK	-1.15	-0.15	--	---	---
PCTSPAN	0.37	0.16	--	---	---
PCTMARR	-0.52	-0.07	--	---	---
PCTFLYH	2.70*	0.53	7	3.20*	0.25
PCTMAH	-4.49*	-0.87	6	-4.59*	0.22
PCTUNEMP	-1.89	-0.23	4	Eliminated: Step 10	0.19
PERCAPT	0.01*	0.40	3	0.005*	0.15
PCTAGFF	-0.60	-0.22	--	---	---
PCTPRS	-3.37	-0.14	8	-6.74*	0.28
PCTTECHN	0.37	0.07	--	---	---
PCTPROD	0.81	0.13	--	---	---
TOTYRNHS	-0.00*	-0.52	9	-0.004*	0.31
PCTOCCUP	-2.45*	-0.27	2	Eliminated: Step 13	0.11
PUBWATER	2.35*	0.24	5	3.17*	0.21
YRAB70	-0.63	-0.19	1	Eliminated: Step 12	0.08

Adjusted R^2 = 0.29

*Indicates relationship is significant at the .05 level.

Table 10

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 2
(N = 118)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	-73.87	0.00	--	---	---
MEDAGE	0.50	0.03	--	---	---
PCTBLK	1.49	0.14	--	---	---
PCTSPAN	1.07	0.60	--	---	---
PCTMARR	0.71	0.07	--	---	---
PCTFLYH	0.15	0.03	--	---	---
PCTMAH	-0.88	-0.15	--	---	---
PCTUNEMP	2.39*	0.49	--	---	---
PERCAPT	0.01*	0.56	3	-1.22*	0.31
PCTAGFF	1.54	0.30	--	---	---
PCTPRS	13.02*	0.40	1	0.05*	0.19
PCTTECHN	4.49*	0.55	--	---	---
PCTPROD	4.07*	0.36	--	---	---
TOTYRNHS	-0.00	-0.20	--	---	---
PCTOCCUP	-1.26	-0.10	--	---	---
PUBWATER	-0.84	-0.03	--	---	---
YRAB70	-1.06*	-0.28	2	11.36*	0.27

Adjusted R^2 = 0.37

*Indicates relationship is significant at the .05 level.

Table 11

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 3
(N = 102)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	512.12*	0.00	--	---	---
MEDAGE	-1.34	-0.06	--	---	---
PCTBLK	-0.05	-0.02	--	---	---
PCTSPAN	-0.26	-0.05	--	---	---
PCTMARR	-1.32	-0.16	--	---	---
PCTFLYH	-1.11	-0.15	6	-1.29*	0.84
PCTMAH	-0.64	-0.17	2	-1.15*	0.80
PCTUNEMP	-1.91	-0.13	7	-1.57*	0.85
PERCAPT	0.00	0.12	3	0.00	0.82
PCTAGFF	0.58	0.04	--	---	---
PCTPRS	2.43	0.06	--	---	---
PCTTECHN	1.04	0.11	--	---	---
PCTPROD	0.31	0.04	--	---	---
TOTYRNHS	0.001*	0.31	1	0.001*	0.74
PCTOCCUP	-2.65*	-0.17	4	-2.55*	0.83
PUBWATER	0.77*	0.10	5	0.80*	0.84
YRAB70	-0.31	-0.09	--	---	---

Adjusted R^2 = 0.82

*Indicates relationship is significant at the .05 level.

Table 12

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 4
(N = 103)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	549.37*	0.00	--	---	---
MEDAGE	-1.62	-0.25	6	-1.28	0.41
PCTBLK	0.78	0.24	5	0.98*	0.37
PCTSPAN	1.16	0.16	7	0.93	0.42
PCTMARR	-0.89	-0.19	--	---	---
PCTFLYH	0.50	0.20	--	---	---
PCTMAH	-1.86	-0.48	2	-2.30*	0.15
PCTUNEMP	0.52	0.06	--	---	---
PERCAPT	0.02*	0.64	3	0.02*	0.19
PCTAGFF	1.61	0.16	--	---	---
PCTPRS	-0.99	-0.04	--	---	---
PCTTECHN	1.69	0.25	--	---	---
PCTPROD	-0.59	-0.06	--	---	---
TOTYRNHS	-0.00*	-0.64	4	-0.002*	0.31
PCTOCCUP	-4.19*	-0.44	1	-3.23*	0.08
PUBWATER	-0.42	-0.03	--	---	---
YRAB70	-0.69	-0.28	--	---	---

Adjusted R^2 = 0.37

*Indicates relationship is significant at the .05 level.

Table 13

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 5
(N = 98)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	112.76	0.00	--	---	---
MEDAGE	-1.03	-0.09	--	---	---
PCTBLK	0.67	0.32	--	---	---
PCTSPAN	0.83	0.14	5	1.32*	0.80
PCTMARR	3.48*	0.64	4	3.46*	0.79
PCTFLYH	0.43	0.11	3	Eliminated: Step 6	0.78
PCTMAH	-2.58*	-1.15	1	-2.53*	0.70
PCTUNEMP	-0.73	-0.06	--	---	---
PERCAPT	0.00	0.16	--	---	---
PCTAGFF	-2.00	-0.07	--	---	---
PCTPRS	-1.69	-0.07	--	---	---
PCTTECHN	-0.17	-0.03	--	---	---
PCTPROD	-2.43*	-0.30	2	-2.87*	0.75
TOTYRNHS	-0.00	-0.17	--	---	---
PCTOCCUP	-0.71	-0.06	--	---	---
PUBWATER	1.10	0.05	--	---	---
YRAB70	-0.19	-0.13	--	---	---

Adjusted R^2 = 0.79

*Indicates relationship is significant at the .05 level.

Table 14

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During December, January and February, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 6
(N = 112)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	358.97	0.00	--	---	---
MEDAGE	-2.10*	-0.36	--	---	---
PCTBLK	0.24	0.06	--	---	---
PCTSPAN	-0.08	-0.02	--	---	---
PCTMARR	-2.35	-0.46	1	-5.18*	0.26
PCTFLYH	-2.84*	-0.97	--	---	---
PCTMAH	0.97	0.34	--	---	---
PCTUNEMP	-3.14*	-1.18	7	-0.85*	0.46
PERCAPT	0.01*	0.44	3	0.02*	0.36
PCTAGFF	1.06	0.11	--	---	---
PCTPRS	6.47*	0.24	6	4.08	0.44
PCTTECHN	2.44*	0.38	8	2.49*	0.49
PCTPROD	-0.20	-0.02	--	---	---
TOTYRNHS	-0.00*	-0.75	4	-0.001*	0.40
PCTOCCUP	-3.31*	-0.28	5	-3.20*	0.43
PUBWATER	3.41	0.13	--	---	---
YRAB70	-1.16*	-0.51	2	-1.07*	0.34

Adjusted R^2 = 0.46

*Indicates relationship is significant at the .05 level.

economic and housing variables all enter into the explanatory model. The results for these regions thus largely lack predictive consistency.

Overall, then, the regional models clearly point to the often noted diversity in the State of Texas and suggest the need for regional models for use in predicting per capita water use. At the same time, however, they suggest that the variables included here are most effective in explaining water use in the more urbanized areas of the State. That is, the most urban areas of the State are in regions 3 and 5, followed by region 6, and it is in these regions that the models are most effective in explaining water use. They are least effective in regions 1 and 2, the most rural regions of the State. There is thus some consistency with the findings related to population size, suggesting that although the factors included here do assist one in predicting water use in larger, more urban population centers, other factors not specified in these models are also playing a role in water use in smaller less urban areas of the State. The need for urban and rural model types is thus suggested by the models containing control variables.

Results for Summer Months (June, July and August)

Tables 15-27 present the results for the analysis of average daily per capita water use for the summer months. Table 15 shows results quite different than those shown for the total model for the winter months. The R^2 is lower, 44 percent compared to 54 percent in the winter model, and the variables showing the greatest explanatory power are economic variables such as the percent of the workforce employed in construction industries and the percent employed in recreation and entertainment industries. Several demographic and housing variables are still significantly related to daily per capita water use, but the range of variables of importance and

Table 15

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Texas Cities
(N = 677)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	996.26	0.00	--	---	---
PCTURB	0.02	0.01	--	---	---
MEDAGE	-2.86*	-0.16	--	---	---
PCTBLK	-1.39*	-0.27	3	-1.38*	0.24
PCTSPAN	1.37*	0.51	15	0.86*	0.43
PCTMARR	5.12*	0.41	--	---	---
PCTFLYH	-4.10*	-0.52	12	-2.98*	0.42
PCTMAH	-1.80*	-0.28	10	Eliminated: Step 21	0.40
PCTUNEMP	-1.57*	-0.15	19	-2.45*	0.44
PERCAPT	0.001	0.04	--	---	---
PCTAGFF	-3.83*	-0.33	7	1.98*	0.35
PCTCONS	-9.73*	-0.43	1	-3.59*	0.15
PCTMANE	-6.18*	-0.67	--	---	---
PCTTRANS	-7.31*	-0.23	--	---	---
PCTCOMM	-1.48	-0.03	11	5.38*	0.41
PCTWHOLE	-10.20*	-0.29	22	-3.55*	0.45
PCTRETAL	-6.83*	-0.30	--	---	---
PCTBUSIN	-3.95	-0.09	4	Eliminated: Step 14, Re-entered: Step 23	0.28
PCTPRS	-0.17	-0.00	2	9.67*	0.21
PCTPROF	-10.56*	-0.89	9	-4.44*	0.39
PCTADMIN	-8.93*	-0.42	24	-1.48	0.45
PCTTECHN	1.17	0.09	--	---	---
PCTSERVC	3.48*	0.18	--	---	---
PCTPROD	-5.79*	-0.36	6	-6.50*	0.33
PCTOPFL	-0.50	-0.04	13	-1.94*	0.43
MEDROOM	35.56*	0.18	16	30.15*	0.43
TOTYRNHS	-0.00	-0.10	17	-0.00*	0.44
PCTOCCUP	-1.99*	-0.09	18	-1.68	0.44
PCTMOBIL	0.42	0.02	--	---	---
PCT1UNIT	-0.18	-0.03	20	-0.93*	0.45
PCTTOTPL	3.61*	0.11	8	4.80*	0.38
PUBWATER	-0.49	-0.02	--	---	---
YRAB70	-1.02*	-0.22	5	-1.32*	0.30

Adjusted R^2 = 0.45

*Indicates relationship is significant at the .05 level.

the relative dominance of the economic variables is more evident.

The relative importance of the economic variables is clearly evident in Tables 16-18 in which the models for the three categories of variables--demographic, economic and housing--are analyzed separately. In general, the models have lower explanatory power than in the winter models, and unlike the winter models, the economic model has a higher R^2 than either the demographic or housing model (although even for the economic model, the percent of variation explained is smaller for the summer than for the winter model). Although there are some reversals in signs in the relationships among the three variable categories when summer models are compared to the winter models, the signs are generally consistent across the summer and winter models. In general, then, the results in Tables 15-18 suggest that the variables included in this model are not as effective in predicting per capita water use levels for the summer as they were for predicting winter use rates.

The models controlling for population size and region of the State (shown in Tables 19-27) reveal several consistencies when compared with the winter models. Thus, as with the winter models, the percent of variation explained is greatest for the model for the largest population centers, and the relative level of explained variation by region is the same. The highest percent of variation explained is for region 3, followed by region 5, then region 6, and then regions 4, 2 and 1. In like manner, the demographic variables are more predictive of per capita water use in the largest size-of-place category and demographic and housing variables of greatest importance in explaining per capita use in the more urban regions (3, 5 and 6) while economic variables are particularly important in regions 2 and 4. Like in the winter models, then, in the summer models it appears

Table 16

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Demographic Variables for 1980 for Texas Cities
(N = 677)

Variable Name	Ordinary Least Squares: Unstandardized Coefficient	Ordinary Least Squares: Standardized Coefficient	Stepwise Regression: Order of Entrance	Stepwise Regression: Unstandardized Coefficient	R^2
Intercept	300.13	--	--	---	---
POP80	-0.001*	-0.13	9	-0.001*	0.20
PCTURB	0.11	0.08	--	---	---
AVGSIZHH	14.78*	0.23	7	18.04*	0.19
MEDAGE	1.55	0.08	3	Eliminated: Step 8	0.10
PCTBLK	0.06	0.01	--	---	---
PCTSPAN	1.76*	0.66	2	1.74*	0.08
PCTMARR	9.06*	0.73	5	10.13*	0.16
PCTFLYH	-2.78*	-0.35	4	-2.56*	0.15
PCTMAH	-3.83*	-0.60	6	-4.53*	0.18
PCTBLHS	-1.92*	-0.34	1	-2.04*	0.04

Adjusted R^2 = 0.19

*Indicates relationship is significant at the .05 level.

Table 17

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Economic Variables for 1980 for Texas Cities
(N = 677)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	753.54	--	--	---	---
PCTUNEMP	-0.48*	-0.05	--	---	---
PERCAPT	0.00	0.06	12	0.004*	0.31
PCTAGFF	-2.99	-0.26	4	Eliminated: Step 11	0.25
PCTCONS	-10.59*	-0.47	1	-7.41*	0.15
PCTMANF	-6.26*	-0.68	8	-2.99*	0.30
PCTTRANS	-7.68*	-0.24	10	-4.14*	0.30
PCTCOMM	-2.09	-0.04	--	---	---
PCTWHOLE	-7.02*	-0.20	14	-2.86*	0.31
PCTRETAL	-3.61	-0.16	--	---	---
PCTBUSIN	-2.49	-0.05	5	Eliminated: Step 9	0.27
PCTPRS	1.96	0.03	2	7.67*	0.21
PCTPROF	-7.38*	-0.62	7	-4.16*	0.29
PCTADMIN	-4.68*	-0.22	--	---	---
PCTTECHN	0.38	0.03	--	---	---
PCTSERVC	1.63	0.08	--	---	---
PCTPROD	-2.76*	-0.17	6	3.01*	0.28
PCTOPFL	0.08	0.01	3	Eliminated: Step 13	0.24

Adjusted R^2 = 0.30

*Indicates relationship is significant at the .05 level.

Table 18

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, August, 1980 on Selected Housing Variables for 1980 for Texas Cities
(N = 677)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	-93.11	--	--	---	---
MEDPERHU	-15.50	-0.09	--	---	---
MEDVALUE	0.00	0.17	3	0.001*	0.09
MEDROOM	1.12*	0.01	--	---	---
TOTYRNHS	-0.00	-0.16	5	-0.001*	0.10
PCTOCCUP	1.82*	0.08	--	---	---
PCTMOBIL	-1.50	-0.08	6	-2.02*	0.11
PCT1UNIT	-1.24	-0.20	4	-1.21*	0.09
PCTTOTPL	0.56	0.12	--	---	---
PUBWATER	2.52*	0.11	1	2.47*	0.03
YRAB70	-1.09*	-0.24	2	-1.29*	0.05

Adjusted R^2 = 0.10

*Indicates relationship is significant at the .05 level.

Table 19

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities with Less than 2,500 Population in 1980
(N = 268)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	537.56*	0.00	--	---	---
PCTBLK	-1.28*	-0.14	5	1.62*	0.36
PCTSPAN	0.31	0.08	--	---	---
PCTFLYH	0.59	0.03	--	---	---
PCTUNEMP	-2.36	-0.13	4	1.76	0.34
PCTAGFF	2.04*	0.21	3	2.51*	0.32
PCTCONS	-0.83	-0.04	--	---	---
PCTCOMM	0.71	0.02	--	---	---
PCTWHOLE	-0.20	-0.00	--	---	---
PCTBUSIN	2.81	0.05	--	---	---
PCTPRS	-2.24	-0.04	--	---	---
PCTPROF	-0.85	-0.05	--	---	---
PCTADMIN	4.13*	0.12	8	4.46*	0.40
PCTPROD	-0.36	-0.02	--	---	---
PCTOPFL	-3.53*	-0.24	--	---	---
MEDROOM	58.74	0.18	9	47.20*	0.40
TOTYRNHS	0.06*	0.14	7	0.06*	0.39
PCTOCCUP	-5.80*	-0.35	2	-5.38*	0.25
PCT1UNIT	-0.46	-0.05	--	---	---
PCTTOTPL	-0.18	-0.01	1	-3.20*	0.15
YRAB70	-1.21*	-0.21	6	-0.88*	0.37

Adjusted $R^2 = 0.37$

*Indicates relationship is significant at the .05 level.

Table 20

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities with 2,500 to 10,000 Population in 1980
(N = 258)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	109.52	0.00	--	---	---
PCTBLK	-1.06	-0.13	8	-1.43*	0.38
PCTSPAN	0.71	0.20	--	---	---
PCTFLYH	-1.30	-0.10	--	---	---
PCTUNEMP	-0.76	-0.05	--	---	---
PCTAGFF	3.03*	0.26	1	3.11*	0.12
PCTCONS	-3.00	-0.13	7	-3.53*	0.36
PCTCOMM	1.52	0.03	--	---	---
PCTWHOLE	-6.38*	-0.14	10	-4.10	0.39
PCTBUSIN	1.20	0.02	--	---	---
PCTPRS	10.07*	0.19	3	11.90*	0.30
PCTPROF	-2.10	-0.16	--	---	---
PCTADMIN	-3.96*	-0.12	9	-3.40*	0.38
PCTPROD	-2.39	-0.13	--	---	---
PCTOPFL	-4.43*	-0.33	2	-4.40*	0.22
MEDROOM	13.50	0.05	--	---	---
TOTYRNHS	0.00	0.04	--	---	---
PCTOCCUP	-0.43	-0.02	--	---	---
PCT1UNIT	-1.17	-0.11	6	-1.30*	0.35
PCTTOTPL	4.96	0.16	5	2.90	0.34
YRAB70	-1.06*	-0.21	4	-0.90*	0.32

Adjusted R^2 = 0.36

*Indicates relationship is significant at the .05 level.

Table 21

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities with >10,000 Population in 1980
(N = 149)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	-114.52	0.00	--	---	---
PCTBLK	-1.99*	-0.44	3	-2.30*	0.31
PCTSPAN	1.03*	0.43	15	-0.36	0.58
PCTFLYH	-3.83*	-0.57	13	-2.86*	0.55
PCTUNEMP	-3.24*	-0.36	14	-2.30*	0.57
PCTAGFF	2.33*	0.17	11	2.26*	0.52
PCTCONS	-2.43	-0.10	1	Eliminated: Step 8	0.22
PCTCOMM	10.72*	0.17	12	10.50*	0.53
PCTWHOLE	-3.96	-0.12	--	---	---
PCTBUSIN	2.95	0.06	4	Eliminated: Step 10	0.37
PCTPRS	10.66*	0.18	2	11.03*	0.28
PCTPROF	-5.78*	-0.52	7	-5.05*	0.48
PCTADMIN	-1.75	-0.10	--	---	---
PCTPROD	-11.43*	-0.72	5	-11.99*	0.39
PCTOPFL	0.79	0.06	--	---	---
MEDROOM	17.48	0.10	--	---	---
TOTYRNHS	-0.00	-0.16	--	---	---
PCTOCCUP	-2.75	-0.13	--	---	---
PCT1UNIT	-0.19	-0.03	--	---	---
PCTTOTPL	11.91*	0.27	9	7.84*	0.50
YRAB70	-1.27*	-0.30	6	-1.47*	0.44

Adjusted R^2 = 0.53

*Indicates relationship is significant at the .05 level.

Table 22

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 1
(N = 139)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	260.04	0.00	--	---	---
PCTBLK	-3.46	-0.22	--	---	---
PCTSPAN	2.00*	0.41	--	---	---
PCTFLYH	-2.86	-0.27	--	---	---
PCTUNEMP	-2.91	-0.18	--	---	---
PCTAGFF	1.07	0.19	2	1.91*	0.08
PCTCONS	3.84	0.14	4	4.20	0.13
PCTCOMM	3.11	0.08	--	---	---
PCTWHOLE	-3.35	-0.13	--	---	---
PCTBUSIN	2.28	0.05	7	7.49*	0.16
PCTPRS	-3.84	-0.08	--	---	---
PCTPROF	-1.20	-0.11	--	---	---
PCTADMIN	-0.89	-0.02	--	---	---
PCTPROD	1.00	0.08	--	---	---
PCTOPFL	-0.57	-0.05	--	---	---
MEDROOM	161.09*	0.44	5	54.75	0.14
TOTYRNHS	0.00	0.34	3	0.00	0.11
PCTOCCUP	1.45	0.08	1	Eliminated: Step 6	0.07
PCT1UNIT	-3.82*	-0.48	--	---	---
PCTTOTPL	-3.04	-0.06	--	---	---
YRAB70	-2.19	-0.32	--	---	---

Adjusted R^2 = 0.12

*Indicates relationship is significant at the .05 level.

Table 23

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 2
(N = 118)

Variable Name	Ordinary Least Squares: Unstandardized Coefficient	Ordinary Least Squares: Standardized Coefficient	Stepwise Regression: Order of Entrance	Stepwise Regression: Unstandardized Coefficient	Stepwise Regression: R^2
Intercept	212.55	0.00	--	---	---
PCTBLK	-12.49*	-0.57	--	---	---
PCTSPAN	-1.22	-0.33	--	---	---
PCTFLYH	1.23	0.12	3	Eliminated: Step 9	0.35
PCTUNEMP	3.21	0.32	--	---	---
PCTAGFF	3.59*	0.34	4	2.92*	0.37
PCTCONS	-6.57	-0.20	5	7.66*	0.41
PCTCOMM	30.89*	0.49	1	30.67*	0.19
PCTWHOLE	-8.50*	-0.18	6	-7.31*	0.43
PCTBUSIN	1.72	0.03	--	---	---
PCTPRS	13.44*	0.20	2	13.59*	0.31
PCTPROF	-4.81*	-0.21	10	-6.12*	0.48
PCTADMIN	0.28	0.01	--	---	---
PCTPROD	-4.60	-0.20	11	-5.40	0.49
PCTPFL	-5.12*	-0.28	7	-5.74*	0.44
MEDROOM	-25.21	-0.10	--	---	---
TOTYRNHS	0.001*	0.45	--	---	---
PCTOCCUP	-0.38	-0.02	--	---	---
PCT1UNIT	0.08	0.01	--	---	---
PCTTOTPL	3.50	0.16	--	---	---
YRAB70	-2.48*	-0.32	8	-2.35*	0.46

Adjusted R^2 = 0.44

*Indicates relationship is significant at the .05 level.

Table 24

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 3
(N = 102)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	267.92	0.00	--	---	---
PCTBLK	0.23	0.07	--	---	---
PCTSPAN	0.15	0.03	--	---	---
PCTFLYH	-2.81*	-0.36	5	-2.48*	0.76
PCTUNEMP	-4.48*	-0.29	4	-4.69*	0.73
PCTAGFF	1.74	0.12	10	1.67	0.79
PCTCONS	0.70	0.06	--	---	---
PCTCOMM	1.78	0.04	--	---	---
PCTWHOLE	-4.66	-0.19	8	-4.19*	0.78
PCTBUSIN	2.56	0.09	7	4.52*	0.78
PCTPRS	5.07	0.13	6	7.26*	0.77
PCTPROF	-1.65	-0.18	--	---	---
PCTADMIN	0.54	0.01	--	---	---
PCTPROD	-3.18*	-0.37	2	-1.94*	0.69
PCTOPFL	-1.12	-0.11	--	---	---
MEDROOM	6.65	0.05	--	---	---
TOTYRNHS	0.00	0.10	1	0.00	0.56
PCTOCCUP	-2.87	-0.18	3	-3.43*	0.71
PCT1UNIT	-0.39	-0.11	--	---	---
PCTTOTPL	5.63	0.14	9	6.09*	0.79
YRAB70	-0.29	-0.09	--	---	---

Adjusted R^2 = 0.76

*Indicates relationship is significant at the .05 level.

Table 25

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 4
(N = 103)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	-446.87	0.00	--	---	---
PCTBLK	1.67*	0.36	7	1.86*	0.44
PCTSPAN	1.64	0.16	11	1.20	0.50
PCTFLYH	-1.19	-0.32	--	---	---
PCTUNEMP	0.38	0.03	--	---	---
PCTAGFF	5.20*	0.35	3	4.90*	0.26
PCTCONS	-1.83	-0.08	--	---	---
PCTCOMM	-2.77	-0.12	10	-2.90	0.48
PCWHOLE	-0.61	-0.02	--	---	---
PCTBUSIN	12.00*	0.23	9	10.22*	0.47
PCTPRS	-4.89	-0.13	--	---	---
PCTPROF	-1.00	-0.18	--	---	---
PCTADMIN	-5.27*	-0.29	--	---	---
PCTPROD	-6.26*	-0.47	4	-4.89*	0.29
PCTOPFL	-0.08	-0.01	--	---	---
MEDROOM	128.63*	0.82	5	45.17*	0.36
TOTYRNHS	-0.00	-0.23	1	Eliminated: Step 8	0.11
PCTOCCUP	-8.50*	-0.60	2	-6.62*	0.20
PCT1UNIT	-1.99	-0.40	--	---	---
PCTTOTPL	11.63*	0.44	6	11.70*	0.39
YRAB70	-0.31	-0.09	--	---	---

Adjusted R^2 = 0.45

*Indicates relationship is significant at the .05 level.

Table 26

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 5
(N = 98)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficient	Standardized Coefficient	Order of Entrance	Unstandardized Coefficient	R^2
Intercept	-2444.97*	0.00	--	---	---
PCTBLK	-0.32	-0.08	--	---	---
PCTSPAN	0.23	0.02	--	---	---
PCTFLYH	-2.01	-0.25	--	---	---
PCTUNEMP	-2.43	-0.10	--	---	---
PCTAGFF	1.88	0.03	--	---	---
PCTCONS	4.93	0.14	--	---	---
PCTCOMM	-4.44	-0.05	--	---	---
PCTWHOLE	0.07	0.00	--	---	---
PCTBUSIN	5.12	0.11	--	---	---
PCTPRS	10.44	0.22	4	14.50*	0.70
PCTPROF	-0.33	-0.03	--	---	---
PCTADMIN	10.43	0.15	--	---	---
PCTPROD	-9.61*	-0.58	1	-8.25*	0.54
PCTOPFL	0.54	0.05	--	---	---
MEDROOM	33.16	0.22	--	---	---
TOTYRNHS	-0.00	-0.01	--	---	---
PCTOCCUP	-4.36	-0.18	--	---	---
PCT1UNIT	-1.23	-0.24	2	-1.29*	0.62
PCTTOTPL	32.78*	0.33	3	30.00*	0.65
YRAB70	-0.66	-0.22	--	---	---

Adjusted R^2 = 0.68

*Indicates relationship is significant at the .05 level.

Table 27

Results of Ordinary Least Squares and Stepwise Regressions of Average Daily Per Capita Water Use During June, July, and August, 1980 on Selected Socioeconomic Variables for 1980 for Cities in Region 6
(N = 112)

Variable Name	Ordinary Least Squares: Unstandardized Coefficient	Ordinary Least Squares: Standardized Coefficient	Stepwise Regression: Order of Entrance	Stepwise Regression: Unstandardized Coefficient	R^2
Intercept	194.28	0.00	--	---	---
PCTBLK	-1.54	-0.21	6	-2.96*	0.41
PCTSPAN	1.77*	0.27	--	---	---
PCTFLYH	-2.97*	-0.54	1	-3.34*	0.20
PCTUNEMP	-2.96*	-0.59	2	-3.65*	0.27
PCTAGFF	-0.38	-0.02	--	---	---
PCTCONS	1.77	0.09	--	---	---
PCTCOMM	3.88	0.08	--	---	---
PCTWHOLE	2.75	0.06	--	---	---
PCTBUSIN	-3.96	-0.09	--	---	---
PCTPRS	5.05	0.10	4	11.07*	0.35
PCTPROF	-2.47	-0.21	--	---	---
PCTADMIN	-5.70*	-0.37	--	---	---
PCTPROD	-7.22*	-0.42	5	-5.71*	0.38
PCTOPFL	-4.54*	-0.45	--	---	---
MEDROOM	125.56*	0.58	3	137.25*	0.30
TOTYRNHS	0.00	0.10	--	---	---
PRCTOCCUP	-7.71*	-0.35	9	-4.07*	0.49
PCT1UNIT	-1.92	-0.38	8	-3.13*	0.47
PCTTOTPL	9.02*	0.24	--	---	---
YRAB70	-2.62	-0.62	7	-2.25*	0.44

Adjusted R^2 = 0.50

*Indicates relationship is significant at the .05 level.

that there is considerable diversity among regions and that predictive ability is greatest in larger, more urban locations.

Overall, then, the results of the secondary analysis suggest that socioeconomic variables do explain a substantial part of the variation in daily per capita use rates across the State of Texas and thus should be considered for inclusion in projections of water demand. At the same time, however, they indicate considerable variability in the predictive capabilities of such variables depending on the period to which they are applied (e.g., winter versus summer) and the area of the State. In general, the results suggest that these variables are of greatest utility when predicting winter water use, in which household consumption factors may be expected to dominate use, and less predictive during summer months when numerous factors in addition to household compositional factors apparently affect water use. In addition, the results suggest that the predictive capabilities of these models is more substantial in larger urban regions than in more rural regions, suggesting that factors omitted from the present models play a larger role in water use in rural areas. In sum, then, the results suggest that socioeconomic variables may indeed be important for inclusion in water projection models but their importance is likely to be greater for large urban areas than for smaller rural areas. Separate projection models for different parts of the State may thus be necessary.

Section III

Results of Primary Data Analysis

The primary data analysis consisted of analysis of data from 814 telephone surveys conducted in 8 selected communities in Texas. These communities included ones in diverse areas of the State and ones with widely varying levels of per capita water use (based on residential water use data from the Texas Water Development Board). Figure 2 presents a listing of these communities, their per capita levels of water use (in gallons) and shows their location within the State. The appendix presents a copy of the questionnaire used in the survey.

From the survey a variety of independent and dependent variables were derived for analysis. These included sociodemographic variables as well as variables measuring each respondent household's possession and level of use of various water-using appliances and behaviors and respondents' attitudes toward water management and use.

The major dependent variable of interest is daily per capita water use. Respondents were asked (questions 7 and 10) to estimate the quantity of water used in their household. As noted in Section I, despite extensive attempts to elicit this information, a majority of respondents simply could not provide information on the extent of water use in their households. It was thus necessary to estimate likely levels of daily per capita water use based on the number of persons in the household, the type of water using appliances in the household and the level of use of these appliances and the extent to which the household performed certain water-using behaviors (e.g., number of meals eaten at home). Data on average levels of use related to each appliance and behavior were obtained from water engineers in the State and the levels of per capita use determined. The standard parameters used in deriving these estimates are shown in Table 28.

Analysis using two alternative estimates of water use derived directly from respondents' answers to questions 7 and 10 were also used but provided results that differed little from the results for the computed water use rates. Thus, although some data related to these two alternative measures are presented in the discussion of the results of the regression analysis (see Tables 39 and 40), it is the computed water use rates that are the central focus of the primary data analysis reported in this section. In addition to the use of per capita water use levels, analysis is also shown of the relationships between sociodemographic variables and the existence of certain water-using appliances and the practice of certain water-using behaviors.

The independent variables used in the analysis include standard sociodemographic variables such as respondent age, household size, type of housing, size of housing unit, housing tenure, level of education, income, occupation, industry, and similar variables. A variable was also included measuring respondents' attitudes toward water use and management. The responses to question 2 in the questionnaire were used as the basis for deriving this variable. Respondents' answers to this question were subjected to factor analysis (with orthogonal rotation) to determine the pattern of responses to the attitudinal items. This analysis, as shown in Table 29, indicated two relatively distinct patterns which we refer to as a proconservation and proconsumption continuum. Items with factor loadings of .25 or greater were used in determining the item composition of each pattern, and all respondents were given a single score on the continuum by using their response to each of the 18 items included in one or the other of the patterns and reverse coding items related to the proconservation dimension. As a result, all respondents were given a score indicating

Table 28

Water Use Standards Used in Computing Per Capita Water Use for Survey Respondent Households

Activity/System	Average Amount of Water Used	Source
Meals/Food Preparation	.666 gallons per person per meal	(1) (2)
Personal (Drinking, etc.)	1 gallon per day per person	(1) (2)
Dishwashers	18 gallons per load	(2)
Handwashing Dishes	10 gallons per wash	(2)
Washing Machine	45 gallons per load	(2)
Tub Baths	< 1/4 full = 20 gallons 1/4 - 1/2 full = 30 gallons 1/2 - 3/4 full = 40 gallons 3/4 + full = 50 gallons	(2)
Showers	with flow restrictor = 2.5 gallons per minute without flow restrictor = 10 gallons per minute	(2)
Leaky Faucet	350 gallons per month (slow drip)	(2)
Flush Toilets	3.5 gallons per flush in watersaving model 5.25 gallons per flush in standard model	(2)
Lawn/Garden Watering	1 gallon per month per square foot	(3) (4)
Hot Tub	337 gallons every 6 months, plus 30 gallons per month refill	(5)
Swimming Pool	15,000 gallons every 2 years, plus 125 gallons per month for in-use months	(5)
Vehicle Washing	50 gallons per vehicle	(2)

Sources: (1) M. Milne (1976); (2) William Hoffman, Water Uses, Projections, and Conservation Section, Texas Water Development Board, Austin, Texas; (3) Richard Duble, Turfgrass Specialist, Texas Agricultural Extension Service, Department of Soil and Crop Science, Texas A&M University, College Station, Texas; (4) C. Wayne Keese, Agricultural Engineer, Texas Agricultural Extension Service, College Station, Texas; (5) Bill Mobley, Mobley Pools, Bryan, Texas.

Table 29

Results (Factor Loadings) of Factor Analysis of Respondents' Attitudes Toward Water Use and Management Issues
(N = 814)

Questionnaire Item	Factor Pattern	
	Factor 1 (Proconsumptive)	Factor 2 (Proconservative)
Right to Use Water	0.47	0.02
Groundwater Depletion a Problem	-0.27	0.28
Families Use More Than Needed	-0.36	0.12
Government Restrictions	0.09	0.28
Water Supply Sufficient	0.46	0.05
Community Water Supply Adequate	0.52	0.02
Cost of Water Low	-0.07	-0.03
Green Lawns Important	0.46	0.08
Always Enough Water	0.61	0.04
Mandatory Rationing	-0.31	-0.05
Water Pollution--Texas	-0.25	0.25
Water Pollution--Area	-0.05	0.28
Watering Lawns Restricted	-0.35	0.07
Leaky Faucet	0.35	0.22
Reduce Water Used	0.29	0.19
Remove Salt	-0.02	0.22
Treat Waste Water	-0.06	0.56
Treat Sewage Water	-0.01	0.56
Restrict Population Growth	-0.10	0.25
Texas Import Water	0.07	0.23

their position along the continuum with higher scores indicating stronger proconservation attitudes. All other variables were used in their raw interval or categorical form.

The analysis of the results of the survey was conducted using simple crosstabular analysis and regression analysis. Crosstabular analysis was used to present the results in a direct manner that is more easily understood, while regression analysis was used to investigate the magnitude of the relationships between the variables. In using each of the forms of analysis, emphasis is placed on discerning the relationships between each of the sociodemographic variables and water use.

The respondents included in the survey were randomly selected from persons having telephone listings in each of the eight cities. These cities, however, are not necessarily representative of the population of the State as a whole and the results should not be seen as generalizable to the population of the State. As shown in Table 30, the survey respondents were more likely to be female, to be married, to be in households of four or more persons, to have college levels of education, to be Hispanic, to have higher incomes, to be employed as operators and fabricators, to be employed as professionals, and to live in single-family homes than the population of the State as a whole. The results of the survey then should be seen as limited to the areas in which the surveys were conducted.

Crosstabular Data

As a first means of examining the relationship between various sociodemographic characteristics and per capita water use, Table 31 is presented. This table provides data on the percent of persons with specific characteristics using low, medium and high levels of water use. The water use data reported here are those computed using the standards

Table 30

Comparison of Characteristics of Survey Respondents to Characteristics of Texas Population 18 Years of Age and Older, 1980

Characteristic	Survey Respondent (N = 814)	Texas Population, 1980 (18 Years of Age and Older) [N = 9,923,085]
Sex		
Male	36.2%	48.4%
Female	63.8	51.6
Marital Status		
Married	74.5%	60.3%
Widowed	13.0	6.8
Divorced	5.7	6.9
Separated	0.7	2.1
Never Married	6.1	23.9
Persons in Household		
One person	14.6%	21.6%
Two person	31.2	30.8
Three person	18.1	17.5
Four person	18.3	15.7
Five person	10.1	8.0
Six or more persons	7.7	6.5
Age		
18 - 24	7.4%	20.0%
25 - 34	18.5	24.5
35 - 44	21.8	16.2
45 - 54	18.0	13.7
55 - 64	16.9	11.8
65 +	17.4	13.8
Years of Education		
0 - 7	11.1%	13.0%
8	4.3	4.9
9 - 11	11.1	18.0
12	30.6	31.2
13 - 15	19.1	18.2
16	14.0	8.5
17 +	9.8	6.3

Table 30 (continued)

Characteristic	Survey Respondent (N = 814)	Texas Population, 1980 (18 Years of Age and Older) [N = 9,923,085]
Race/Ethnicity		
White	66.9%	80.8%
Black	6.9	11.1
Hispanic	25.6	17.7
Other	0.6	
Household Income (1985)		
< $ 5,000	9.9%	13.8%
$ 5,000 - $ 9,999	7.9	15.7
$10,000 - $14,999	11.4	15.4
$15,000 - $19,999	9.7	13.8
$20,000 - $24,999	11.7	12.1
$25,000 - $34,999	19.9	15.6
$35,000 - $49,999	18.1	8.7
$50,000 +	11.4	4.8
Occupation		
Managerial/Professional	24.8%	22.2%
Technical/Sales/ Administrative	15.9	31.4
Service	5.9	11.4
Farming	2.0	2.8
Precision/Production	7.2	15.3
Operators/Fabricators	44.2	16.9
Industry		
Agriculture/Mining	5.9%	6.3%
Construction	5.1	8.7
Manufacturing	12.0	18.2
Transportation/ Communication	9.5	7.7
Wholesale Trade	2.9	5.3
Retail Trade	13.3	15.5
Finance/Insurance/ Real Estate	4.8	6.1
Business/Repair	5.1	4.7
Personal Services	4.0	4.0
Entertainment	1.3	0.7
Professional/Related Services	32.0	18.9
Public Administration	4.1	4.5

Table 30 (continued)

Characteristic	Survey Respondent (N = 814)	Texas Population, 1980 (18 Years of Age and Older) [N = 9,923,085]
House/Tenure		
Own	86.6%	64.3%
Rent	13.4	35.7
Type of Residence		
Single-family	89.5%	75.6%
Multiple-family	4.3	19.3
Mobile Home/Other	6.2	5.1

Table 31

Low, Medium, and High Levels of Per Capita Water Use by Selected Sociodemographic Characteristics of Survey Respondents

Variable Category	Low (< 72 gallons per day)	Medium (72-114 gallons per day)	High (> 114 gallons per day)	Statistical Significance
Sex (N = 814)				NS
Male (N = 295)	36.6	32.5	30.9	
Female (N = 519)	31.2	33.9	34.9	
Marital Status (N = 813)				NS
Married (N = 606)	35.2	33.2	31.6	
Widowed (N = 106)	30.2	34.9	34.9	
Divorced (N = 46)	32.6	30.4	37.0	
Separated (N = 6)	33.3	16.7	50.0	
Never Married (N = 49)	16.3	38.8	44.9	
Persons in Household (N = 814)				*
1 (N = 119)	20.2	31.9	47.9	
2 (N = 254)	22.4	37.0	40.6	
3 (N = 147)	36.1	39.5	24.4	
4 (N = 149)	43.6	32.2	24.2	
5 (N = 82)	51.2	24.4	24.4	
6 (N = 37)	43.2	21.6	35.1	
7 (N = 15)	40.0	26.7	33.3	
8 (N = 6)	66.7	16.7	16.6	
9 (N = 2)	50.0	0.0	50.0	
10 (N = 2)	100.0	0.0	0.0	
11 (N = 1)	0.0	100.0	0.0	
Age (N = 799)				NS
18 - 24 (N = 59)	33.9	25.4	40.7	
25 - 34 (N = 148)	37.2	31.8	31.0	
35 - 44 (N = 174)	35.6	33.9	30.5	
45 - 54 (N = 144)	34.0	33.3	32.7	
55 - 64 (N = 135)	29.6	36.3	34.1	
65 + (N = 139)	27.3	37.4	35.3	

Table 31 (continued)

Variable Category	Low (< 72 gallons per day)	Medium (72-114 gallons per day)	High (> 114 gallons per day)	Statistical Significance
Place of Residence (N = 813)				NS
Within City (N = 667)	32.2	33.9	33.9	
Built-up Area Near City (N = 85)	41.2	29.4	29.4	
Open Country (N = 61)	32.8	34.4	32.8	
Years of Education (N = 808)				*
0 - 7 (N = 90)	48.9	24.4	26.7	
8 (N = 35)	34.3	45.7	20.0	
9 - 11 (N = 90)	36.7	25.6	37.7	
12 (N = 247)	25.9	39.7	34.4	
13 - 15 (N = 154)	28.6	35.7	35.7	
16 (N = 113)	35.4	33.6	31.0	
17 + (N = 79)	38.0	25.3	36.7	
Race/Ethnicity (N = 810)				*
White (N = 542)	27.7	38.4	33.9	
Black (N = 56)	48.2	25.0	26.8	
Hispanic (N = 207)	44.4	23.2	32.4	
Other (N = 5)	20.0	20.0	60.0	
Income (N = 719)				*
< $5000 (N = 71)	46.5	25.4	28.2	
$ 5,000 - $ 9,999 (N = 57)	43.8	28.1	28.1	
$10,000 - $14,999 (N = 82)	46.3	20.7	32.9	
$15,000 - $19,999 (N = 70)	30.0	32.9	37.1	
$20,000 - $24,999 (N = 84)	27.4	39.3	33.3	
$25,000 - $29,999 (N = 75)	21.3	32.0	46.7	
$30,000 - $34,999 (N = 68)	35.3	45.6	19.1	
$35,000 - $39,999 (N = 57)	35.1	22.8	42.1	
$40,000 - $49,999 (N = 73)	31.5	32.9	35.6	
$50,000 + (N = 82)	24.4	51.2	24.4	

Table 31 (continued)

Variable Category		Low (< 72 gallons per day)	Medium (72-114 gallons per day)	High (> 114 gallons per day)	Statistical Significance
Occupation (N = 803)					NS
Managerial/ Professional	(N = 199)	33.1	38.2	28.7	
Technical/Sales	(N = 128)	32.8	30.5	36.7	
Service	(N = 47)	38.3	29.8	31.9	
Farming	(N = 16)	37.5	37.5	25.0	
Precision Production	(N = 58)	39.7	29.3	31.0	
Operators/ Fabricators	(N = 355)	31.8	33.0	35.2	
Industry (N = 475)					NS
Agriculture and Mining	(N = 28)	40.7	29.6	29.7	
Construction	(N = 24)	25.0	33.3	41.7	
Manufacturing	(N = 57)	31.6	31.6	36.8	
Transportation/ Communications	(N = 45)	42.2	33.3	24.5	
Wholesale Trade	(N = 14)	28.6	50.0	21.4	
Retail Trade	(N = 63)	39.7	28.6	31.7	
F.I.R.E.	(N = 23)	30.4	34.8	34.8	
Business/Repair	(N = 24)	37.5	20.8	41.7	
Personal Service	(N = 19)	31.6	26.3	42.1	
Entertainment	(N = 6)	33.3	50.0	16.7	
Professional Service	(N = 152)	36.8	34.9	28.3	
Public Administration	(N = 20)	40.0	25.0	35.0	
Type of Residence (N = 814)					NS
Single-family	(N = 728)	33.1	34.2	32.7	
Townhouse/ Condominium	(N = 9)	22.2	11.1	66.7	
Duplex/Fourplex	(N = 19)	21.1	36.8	42.1	
Apartment	(N = 7)	57.1	14.3	28.6	
Mobile Home	(N = 49)	36.7	26.5	36.7	
Other	(N = 1)	50.0	50.0	0.0	

Table 31 (continued)

Variable Category	Low (< 72 gallons per day)	Medium (72-114 gallons per day)	High (> 114 gallons per day)	Statistical Significance
Size of Home (sq. ft.) (N = 526)				NS
0 - 1,000 (N = 68)	35.3	25.0	39.7	
1,001 - 1,500 (N = 150)	37.3	32.7	30.0	
1,501 - 2,000 (N = 180)	34.4	31.7	33.9	
2,001 - 2,500 (N = 72)	22.2	47.2	30.6	
> 2,500 (N = 56)	32.1	37.5	30.4	
Home Tenure (N = 811)				*
Own (N = 702)	30.9	34.5	34.6	
Rent (N = 109)	46.8	27.5	25.7	
Consumptive-Conservative Attitude (N = 773)				NS
Proconsumptive (N = 414)	30.1	34.1	35.8	
Proconservative (N = 359)	37.6	32.9	29.5	

NS Indicates that the chi-square between variable and categorized per capita water use was not significant at the .05 level.

* Indicates that the chi-square between variable and categorized per capita water use was significant at the .05 level.

(see Table 28) noted above. Also shown is an indication of whether the chi-square for each variable's relationship with the categorized level of water use is not significant (NS) or is significant (*) at the .05 level.

An examination of the data in Table 31 shows that only five of the sociodemographic variables are significantly related to per capita water use. These variables are the number of persons in the household, years of education, race and ethnicity, income, and home ownership. In general, the data on these factors suggests that larger households use less water per capita, while households with respondents with higher levels of education, who are Anglo, who have higher incomes, and who own their residences have higher levels of water use. Since higher levels of education, the racial status of white, higher incomes, and home ownership generally indicate higher levels of economic well-being, it appears that these data suggest that those with greater financial resources tend to use more water per capita, and that the financial resources of an area's population may be a useful indicator of levels of per capita water use.

Several other variables in Table 31, although not statistically significant, show interesting relationships to water use. For example, young adults appear to have larger per capita water use than older adults, and it appears that those who have proconsumptive attitudes toward water management and conservation tend to use more water than those with proconservation attitudes toward water use.

Overall, the data in Table 31 suggest that variables related to socioeconomic status are useful in explaining alternative levels of water use. These are key sociodemographic variables and thus suggest that such variables are important in understanding patterns of water use and in projecting such use.

One key determinant of water use may be the extent to which a household uses different types of appliances and practices certain types of water-using behavior. Table 32 presents data showing the percent of respondents who have different types of appliances and the percent who practice certain types of behavior related to water use. As in Table 31, indicators of the statistical significance of such relationships are also shown in the table.

An analysis of the data in Table 32 shows that certain characteristics are likely to be associated with owning certain items and doing certain types of behavior. As in the data in Table 31, the results shown in Table 32 indicate that the ownership of water-using items and the display of certain water-using behaviors are generally associated with indicators of economic resources. Thus, smaller household size, more years of education, a racial and ethnic status of white, higher incomes, and higher status occupations are more likely to be associated with the use of such items and the practice of water-using behaviors, while other characteristics are less likely to be associated with the use of such items and behaviors. Unlike in Table 31, however, additional characteristics are more often important. Marital status (i.e., being married), for example, is clearly related to ownership of a washing machine, and age is related to the use of a dishwasher (with younger and older persons being less likely to use a dishwasher than middle-age persons). Overall, then, it appears that sociodemographic variables, particularly those associated with socioeconomic resources and well-being are related both directly to water use and indirectly through their association with ownership of water-using appliances and the performance of water-using behaviors.

Table 32

Percent of Respondent Households with Selected Appliances or Performing Selected Water Use Behaviors by Respondent Characteristics

Percent of Respondents/ Households	Water-Using Appliance/System											
	Automatic Dishwasher	Washing Machine	Bathtub	Shower	No Leaking Faucet	Flush Toilet	Hot Tub	Swimming Pool	Automatic Lawn Sprinkling System	Home Garden	Wash Vehicle	(N)
Sex (N = 814)	NS	NS	*	*	NS	NS	NS	NS	NS	NS	NS	
Male	53.9	93.2	91.9	92.9	82.0	99.0	2.4	3.4	14.6	22.7	41.7	(295)
Female	49.9	92.3	96.3	85.4	78.8	99.6	1.7	4.0	11.6	19.5	42.8	(519)
Marital Status (N = 813)	*	*	NS	*	NS	*	NS	NS	*	NS	*	
Married	55.8	96.0	94.1	92.9	80.2	99.3	2.5	4.3	12.4	22.3	45.7	(606)
Widowed	39.6	84.9	97.2	68.9	80.2	100.0	0.9	1.9	16.9	14.2	28.3	(106)
Divorced	45.6	80.4	95.6	78.3	82.6	100.0	0.0	0.0	10.9	19.6	37.0	(46)
Separated	33.3	83.3	100.0	66.7	83.3	83.3	0.0	0.0	0.0	16.7	16.7	(6)
Never Married	28.6	79.6	95.9	81.6	75.5	100.0	0.0	6.1	10.2	16.3	40.8	(49)
Persons in Household (N = 814)	*	*	*	*	*	NS	NS	*	NS	NS	*	
1	40.3	80.7	97.5	69.8	83.2	100.0	0.0	1.7	14.3	12.6	27.7	(119)
2	61.0	94.1	95.7	91.3	81.9	99.6	2.4	2.8	13.0	23.2	40.2	(254)
3	55.1	94.6	94.6	94.6	83.0	99.3	2.0	1.4	14.3	19.7	49.7	(147)
4	56.4	94.6	98.0	89.3	72.5	99.3	1.2	6.7	12.1	22.8	50.3	(149)
5	39.0	97.6	89.0	87.8	80.5	100.0	8.1	3.7	7.3	20.7	42.7	(82)
6	35.1	94.6	83.8	94.6	89.2	97.3	0.0	16.2	16.2	18.9	45.9	(37)
7	26.7	93.3	86.7	93.3	53.3	93.3	0.0	6.7	6.7	33.3	53.3	(15)
8	16.7	100.0	83.3	83.3	66.7	100.0	0.0	0.0	16.7	16.7	33.3	(6)
9	----	50.0	100.0	50.0	50.0	100.0	0.0	0.0	0.0	50.0	0.0	(2)
10	----	100.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	(2)
11	----	100.0	100.0	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	(1)
Age (N = 799)	*	NS	*	*	NS	NS	NS	*	NS	NS	NS	
18 - 24	36.2	53.7	93.2	50.5	79.3	98.3	0.0	5.2	3.4	22.4	41.4	(59)
25 - 34	47.3	93.9	94.6	93.2	77.0	99.3	2.0	2.7	8.8	16.2	46.6	(148)
35 - 44	62.1	96.6	96.6	93.7	73.0	98.8	4.0	5.7	11.5	19.0	47.7	(174)
45 - 54	54.9	94.4	94.4	94.4	79.2	100.0	2.8	4.9	13.2	27.8	45.1	(144)
55 - 64	52.6	93.3	92.6	85.2	87.4	99.3	1.5	1.5	19.3	19.3	38.5	(135)
65 +	42.5	85.6	95.7	71.9	84.9	100.0	0.0	2.2	15.1	21.6	32.4	(139)

Table 32 (continued)

Percent of Respondents/ Households	Water-Using Appliance/System											
	Automatic Dishwasher	Washing Machine	Bathtub	Shower	No Leaking Faucet	Flush Toilet	Hot Tub	Swimming Pool	Automatic Lawn Sprinkling System	Home Garden	Wash Vehicle	(N)
<u>Place of Residence</u> (N = 813)	*	NS	NS	NS	NS	NS	NS	*	NS	*	NS	
Within City Built-up Area	49.3	92.5	94.6	88.2	79.6	99.2	1.8	2.8	12.9	19.3	42.9	(667)
Near City	57.7	96.5	94.1	85.9	83.5	100.0	2.3	10.6	12.9	21.2	41.2	(85)
Open Country	63.9	88.5	96.7	90.2	80.3	100.0	3.3	4.9	9.8	34.4	39.3	(61)
<u>Years of Education</u> (N = 808)	*	*	*	*	NS	*	*	*	*	*	*	
0 - 7	12.2	82.2	82.2	76.7	81.1	99.0	0.0	0.0	2.2	14.4	32.2	(90)
8	20.0	82.9	85.7	71.4	91.4	100.0	0.0	0.0	5.7	40.0	37.1	(35)
9 - 11	23.3	96.7	92.2	81.1	85.6	96.7	1.1	0.0	6.7	15.6	32.2	(90)
• 12	55.1	92.3	97.2	89.5	80.9	100.0	0.8	3.2	9.7	21.9	52.2	(247)
13 - 15	64.3	95.4	97.4	90.3	77.9	99.3	1.9	6.5	16.2	24.7	41.6	(154)
16	74.3	97.3	98.2	96.5	75.2	100.0	5.3	7.1	21.2	17.7	41.6	(113)
17 +	69.6	94.9	98.7	96.2	74.7	100.0	5.1	6.3	27.8	17.7	41.7	(79)
<u>Race/Ethnicity</u> (N = 810)	*	*	*	*	NS	NS	NS	NS	*	*	NS	
White	66.4	96.3	98.3	90.6	81.4	99.3	2.4	4.6	15.9	23.1	43.0	(542)
Black	19.6	78.6	94.6	51.8	71.4	100.0	0.0	0.0	3.6	28.6	42.9	(56)
Hispanic	20.3	87.4	85.5	90.8	79.2	99.5	1.5	2.9	6.8	12.1	42.5	(207)
Other	100.0	80.0	80.0	100.0	80.0	100.0	0.0	0.0	0.0	0.0	0.0	(5)
<u>Family Income</u> (N = 719)	*	*	*	*	NS	NS	*	*	*	NS	*	
< $5000	9.9	76.0	90.1	60.1	78.9	100.0	0.0	0.0	8.5	19.7	22.5	(71)
$ 5,000 - $ 9,000	22.8	84.2	89.5	73.7	78.9	100.0	1.7	0.0	1.8	15.8	31.6	(57)
$10,000 - $14,999	20.7	90.2	89.0	84.1	86.6	98.8	0.0	0.0	8.5	15.8	42.7	(82)
$15,000 - $19,999	41.4	87.1	91.4	87.1	78.6	100.0	0.0	4.3	5.7	22.9	48.6	(70)
$20,000 - $24,999	41.7	94.1	95.2	92.9	72.6	98.8	0.0	0.0	8.3	21.4	48.8	(84)
$25,000 - $29,999	56.0	97.3	98.7	96.0	73.3	98.7	1.3	0.0	10.7	28.0	57.3	(75)
$30,000 - $34,999	69.1	98.5	100.0	95.6	80.9	100.0	0.0	2.9	10.3	16.2	50.0	(68)
$35,000 - $39,999	70.1	98.2	100.0	96.5	78.9	98.2	1.8	5.3	15.8	22.8	36.8	(57)
$40,000 - $49,999	87.7	100.0	98.6	98.6	84.9	100.0	5.5	2.7	19.2	16.4	46.6	(73)
$50,000 +	89.0	100.0	97.6	97.6	75.6	100.0	8.5	15.9	31.7	22.0	41.5	(82)

Table 32 (continued)

Percent of Respondents/ Households	Water-Using Appliance/System											
	Automatic Dishwasher	Washing Machine	Bathtub	Shower	No Leaking Faucet	Flush Toilet	Hot Tub	Swimming Pool	Automatic Lawn Sprinkling System	Home Garden	Wash Vehicle	(N)
Occupation (N = 803)	*	*	NS	*	NS	NS	*	NS	*	NS	NS	
Managerial/ Professional	68.3	96.0	96.0	92.5	76.4	99.5	5.0	4.0	14.6	21.1	46.7	(199)
Technical/Sales	57.8	96.1	98.4	94.5	75.8	98.4	3.1	7.0	14.1	14.8	46.9	(128)
Service	25.5	89.4	87.2	85.1	70.2	97.9	2.1	2.1	6.4	17.0	46.8	(47)
Farming	68.7	100.0	93.7	81.2	93.7	100.0	0.0	6.2	31.2	18.8	31.2	(16)
Precision Production	43.1	96.6	93.1	96.5	84.5	98.3	0.0	1.7	6.9	32.8	36.2	(58)
Operators/ Fabricators	43.9	89.0	93.8	83.1	83.9	100.0	0.3	3.1	5.11	21.1	39.7	(355)
Industry (N = 475)	*	NS	*	*	NS	NS	NS	NS	*	*	NS	
Agriculture and Mining	77.8	100.0	100.0	81.5	88.9	96.3	0.0	3.7	25.9	29.6	33.3	(28)
Construction	16.7	95.8	91.7	95.8	83.3	95.8	0.0	0.0	12.5	20.8	33.3	(24)
Manufacturing	82.5	96.5	98.2	98.2	80.7	100.0	0.0	5.3	17.5	33.3	38.6	(57)
Transportation/ Communications	64.4	95.6	91.1	95.6	84.4	100.0	4.4	2.2	6.7	22.2	46.7	(45)
Wholesale Trade	50.0	100.0	85.7	100.0	85.7	92.8	7.1	0.0	14.3	7.1	42.9	(14)
Retail Trade	41.3	93.7	93.6	93.7	82.5	98.4	0.0	6.3	9.5	14.3	42.9	(63)
F.I.R.E.	78.3	95.7	100.0	91.3	78.3	100.0	4.4	0.0	8.7	4.4	43.5	(23)
Business/Repair	45.8	95.8	95.8	100.0	70.8	100.0	0.0	4.2	25.0	29.2	41.7	(24)
Personal Service	20.3	89.5	84.2	73.7	73.7	100.0	0.0	0.0	0.0	0.0	52.6	(19)
Entertainment	33.3	83.3	83.3	100.0	100.0	100.0	0.0	0.0	0.0	0.0	50.0	(6)
Professional Service	61.1	96.7	97.4	90.8	71.7	99.3	5.9	5.3	11.8	19.7	48.0	(152)
Public Administration	45.0	85.0	90.0	95.0	70.0	100.0	5.0	5.0	10.0	30.0	60.0	(20)
Type of Residence (N = 814)	NS	*	NS	*	NS	NS	NS	NS	*	NS	NS	
Single-family	51.1	93.4	94.8	87.5	79.5	99.3	2.2	4.3	13.3	20.6	43.0	(728)
Townhouse/ Condominium	44.4	88.9	100.0	100.0	55.6	100.0	0.0	0.0	11.1	22.2	33.3	(9)
Duplex/Fourplex	57.9	78.9	89.5	94.7	89.5	100.0	0.0	0.0	10.5	5.3	42.1	(19)
Apartment	28.6	57.1	100.0	57.1	71.4	100.0	0.0	0.0	0.0	0.0	28.6	(7)
Mobile Home	57.1	91.8	95.9	95.9	87.8	100.0	0.0	0.0	2.0	30.6	34.7	(49)
Other	50.0	100.0	50.0	100.0	100.0	100.0	0.0	0.0	100.0	0.0	100.0	(2)

Table 32 (continued)

Percent of Respondents/ Households	Water-Using Appliance/System											
	Automatic Dishwasher	Washing Machine	Bathtub	Shower	No Leaking Faucet	Flush Toilet	Hot Tub	Swimming Pool	Automatic Lawn Sprinkling System	Home Garden	Wash Vehicle	(N)
Size of Home (sq. ft.) (N = 526)	*	*	*	NS	NS	NS	*	*	*	*	NS	
0 - 1,000	27.9	80.9	82.4	91.1	82.3	98.5	0.0	1.5	5.9	25.0	39.7	(68)
1,001 - 1,500	50.7	98.0	96.0	91.3	80.0	100.0	1.3	1.3	8.0	18.7	44.7	(150)
1,501 - 2,000	72.8	97.2	97.2	94.4	78.3	98.9	2.8	2.2	14.4	20.6	37.2	(180)
2,001 - 2,500	80.6	97.2	97.2	95.8	12.6	100.0	1.4	6.9	22.2	29.2	54.2	(72)
> 2,500	82.1	98.2	96.4	96.4	89.3	100.0	10.7	26.8	42.9	25.0	41.1	(56)
Home Tenure (N = 811)	*	*	NS	NS	NS	NS	NS	NS	*	NS	NS	
Own	54.8	94.3	94.6	88.5	80.3	99.6	2.14	4.0	13.5	21.1	42.2	(702)
Rent	30.3	81.6	96.3	85.3	77.1	98.2	0.92	2.8	6.4	16.5	42.2	(109)
Consumptive-Conservative Attitude (N = 773)	*	NS	NS	*	*	NS	NS	NS	NS	NS	NS	
Proconsumptive	44.7	90.6	93.5	84.1	81.4	99.3	1.7	4.3	11.4	22.2	43.7	(414)
Proconservative	59.0	94.1	96.1	93.0	78.8	99.7	2.5	2.8	13.4	19.2	49.7	(359)

* = significance at the .05 level

NS = not statistically significant

In general, then, the crosstabular analysis suggests that sociodemographic variables, particularly those indicative of socioeconomic resources, may be useful in explaining water use. The extent to which such variables may assist one in predicting such water use is examined in the section below.

Results of Regression Analysis

To further examine the relationships between sociodemographic variables and per capita water use, multiple regression analysis was used. As in previous uses of regression analysis, a correlation matrix was first computed to assess potential problems of multicollinearity. A review of this matrix indicated that no two independent variables were correlated at a level of 0.6 or above and thus all variables were employed in the analysis.

In using regression analysis, it was necessary to transform some variables prior to their use in regression. Thus, several categorical variables were used in dummy variable form. These included sex (in which females were coded as 0 and males as 1), race [in which a first dummy variable (referred to as "Race: Black" in the tables) and a second dummy variable (referred to as "Race: Hispanic" in the tables) were used with white being the residual (or 0) category for each dummy], housing tenure (in which ownership was coded as 1 and renting as 0), presence or absence of given appliances or the performance of selected types of water-using behavior (in which the presence of the appliance or the performance of the behavior was coded as 1 and the absence as 0), and a set of dummy variables indicating the effect of the city of residence (this involved 7 city dummy variables with the city of El Paso being used as the residual category in each case and with dummy variables 1-7 representing the cities of Alice, Hearne, Longview, Mathis, Rocksprings, Sonora, and Waco respectively).

Other variables were either interval-level variables which could be used directly [such as persons per household, age, years of education, square feet in the housing unit, and attitudes toward water use and management (with higher scores indicating more proconservation attitudes)] or variables with values that closely approximated interval-level variables because of the numerous categories used in recording them (see the questionnaire in the appendix). These latter variables included income, marital status, housing type, occupation, and industry [occupation and industry were reordered for the regression analysis with occupational categories being ordered from highest to lowest status (that is, occupation was coded in the order of managerial/professional, technical/sales, precision/production, operators/fabricators, service, and farming with managerial/professional being coded as 1 and farming as 6) and industry was coded from the most basic to the most service-oriented industries (agriculture, construction and manufacturing were combined into category 1, transportation was coded as 2, wholesale and retail trade as 3, finance, insurance and real estate, business and personal services as 4, and entertainment, professional and public administrative services as 5)].

Three forms of regression were used. These included ordinary least squares regression and stepwise regression (with a significance level of 0.15 used as the limitation for the entrance of variables into the stepwise equation) and logistic regression for cases in which the dependent variable was categorical in form. In examining the results of the logistic regression, the reader should be aware that although levels of significance for individual variables are interpreted as in other regression models (with significance generally indicating that the variable may be important for explaining the dependent variable), the interpretation of the utility of a total model is different than for other forms of regression analysis. Because the intent of this form of regression is to see how closely one can fit empirical data to a theoretical model, a nonsignificant chi-square statistic for the overall model is thus interpreted as indicative of a successful model-fitting process. Thus, the finding of a nonsignificant chi-square for a total logistic regression model suggests that the model can be usefully applied to the prediction of the dependent variable.

In the tables that follow, relationships between the independent variables are examined in relation to three alternatively computed measures of water use. Tables 33-38 (with the exception of Table 34 which presents the results of logistic regression in which the presence or absence of certain appliances and behaviors is used as the dependent variable and Table 35 which examines the effects of such variables on water use) examine per capita water use as computed on the basis of respondent household size and presence or absence of certain appliances and water-using behaviors (see description in the methodology section). Tables 39 and 40 attempt to discern whether the means of computing the dependent variable have affected the results by examining per capita water use (put in per capita form) as reported by respondents from examining their utility bills (questionnaire item number 7) or as estimated by respondents (questionnaire item number 10). Both results for the 357 respondents who directly answered either question 7 or 10 (Table 39) and results for those 223 respondents who answered only question 7 (Table 40) and for which data on water use are likely to be most accurate were examined. Models in which means from the 357 and 223 respondents (by city) were used to estimate water use for nonrespondents were also examined. By examining results for each of these dependent variables, the limitations related to our choice of dependent variables can be evaluated.

Results Using **Computed** Per Capita Water Use

Table 33 presents data showing the results of ordinary least squares and stepwise regression analysis of the effects of standard socioeconomic indicators on computed per capita water use rates. An examination of the data in this table suggests that such variables explain only a small proportion of the variation in water use, only 8 percent. The data for this model do show, however, that variables such as a single marital status, a smaller number of persons in the household, younger age of the household head, the racial status of Hispanic, and home ownership significantly increase per capita water use. The results are thus largely consistent with those noted in the secondary data analysis.

The data in Tables 34 and 35 address water use indirectly by examining the extent to which the socioeconomic variables explain the use of key appliances and the performance of certain water-using forms of behavior (Table 34) and the extent to which the use of such appliances and the performance of water-using behavior may allow one to predict water use (Table 35).

The data in Table 34 indicate (by the nonsignificant chi-squares for the total model) that socioeconomic variables such as higher levels of education, higher incomes, larger size homes and home ownership do increase the likelihood of having access to certain appliances and of performing certain types of water-using behaviors while Hispanic or Black status tends to reduce the likelihood of such responses (models for hot tubs and flush toilets are not shown because the models failed to converge after 20

Table 33

Results of Ordinary Least Squares and Stepwise Regressions of Computed Per Capita Water Use on Selected Socioeconomic Variables for Survey Respondents
(N = 744)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficients	Standardized Coefficients	Order of Entrance	Unstandardized Coefficients	R^2
Intercept	129.05*	0.00	--	---	---
Sex	-5.11	-0.02	--	---	---
Marital Status	13.90*	0.15	2	12.56*	0.05
Persons Per Household	-13.50*	-0.23	1	-13.40*	0.04
Age	-0.50*	-0.09	4	-0.59*	0.08
Education	1.37	0.06	--	---	---
Race: Black	-23.33	-0.06	6	-24.88	0.09
Race: Hispanic	27.14*	0.12	5	18.64*	0.09
Family Income	1.65	0.05	--	---	---
Housing Type	-2.08	-0.02	--	---	---
Square Feet	0.00	0.01	--	---	---
Occupation	2.35	0.03	--	---	---
Housing Tenure	36.53*	-0.13	3	40.66*	0.07
Attitude	-0.72	-0.04	--	---	---

Adjusted R^2 = 0.08

* Indicates statistical significance at the .05 level.

Table 34

Results of Maximum Liklihood Logistic Regression of the Use of Selected Appliances and Water Using Behavior (in Dummy Variable Form) on Selected Socioeconomic Variables for Survey Respondents
(N = 781)

	Unstandardized Regression Coefficients								
Effect	Automatic Dishwasher	Washing Machine	Bathtub	Shower	Leaky Faucets	Swimming Pool	Automatic Lawn Sprinkler	Home Garden	Wash Vehicles
Intercept	-3.06*	1.20	2.15	0.30	-1.75*	2.93	-8.18*	-1.74*	-0.19
Sex	-0.24	-0.14	-1.03*	0.38	-0.23	-0.71	-0.01	0.30	-0.09
Marital Status	-0.14	-0.29*	0.30	-0.28*	0.08	0.50*	0.26*	-0.04	-0.11
Persons Per Household	-0.14	0.28*	-0.13	-0.07	0.08	0.39*	0.14	0.16*	0.04
Age	0.00	-8.20	0.01	-0.02*	-0.01	-0.00	0.03*	0.00	-0.01
Education	0.08*	0.19	0.10*	0.10*	0.05	0.12	0.13*	-0.03	0.03
Race: Black	-1.34*	-1.20*	-1.17	-1.42*	0.35	-16.34	-0.74	0.29	0.10
Race: Hispanic	-1.11*	-1.06*	-1.28*	1.25*	0.12	0.59	-0.01	-1.20*	0.05
Income	0.30*	0.22*	0.18*	0.27*	-0.03	0.30*	0.17*	-0.05	0.04
Housing Type	0.21*	-0.14	-0.05	0.32*	-0.09	-13.75	-0.13	0.07	-0.08
Square Feet	4.10*	3.10	-3.20	3.00	-5.20	0.001*	4.80*	7.80	-1.20
Tenure	0.95*	1.03*	-0.61	0.21	0.06	-0.92	0.09	0.42	-0.01
Occupation	-0.05	-0.10	0.01	-0.02	-0.07	0.18	0.16	-0.01	-0.02
Chi-Square/ Likelihood Ratio	740.73	315.57	244.24	422.80	701.70	158.48	490.43	759.79	1044.99
df	767	767	767	767	767	767	767	767	767
Significance Level	NS	NS	NS	NS	NS	NS	NS	NS	*

* = Indicates statistical significance at the .05 level.

NS = Not statistically significant.

Table 35

Results of Ordinary Least Squares and Stepwise Regressions of Computed Per Capita Water Use on Variables Indicating Possession of Selected Appliances and Performance of Selected Water-Using Behavior for Survey Respondents
(N = 813)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficients	Standardized Coefficients	Order of Entrance	Unstandardized Coefficients	R^2
Intercept	54.74	0.0	--	---	---
Automatic Dishwasher	5.69	0.03	--	---	---
Washing Machine	14.89	0.04	--	---	---
Bathtub	-24.60	-0.06	--	---	---
Shower	36.93*	0.13	1	41.97*	0.02
Leaky Faucets	9.79	0.04	--	---	---
Flush Toilets	30.07	0.02	--	---	---
Hot Tub	-22.67	-0.03	--	---	---
Swimming Pool	-25.42	-0.05	--	---	---
Lawn Sprinklers	8.69	0.03	--	---	---
Home Garden	2.92	0.01	--	---	---
Wash Vehicles	-2.12	-0.01	--	---	---

Adjusted R^2 = 0.02

* Indicates statistical significance at the .05 level.

iterations, suggesting that the variables in the model do not allow one to adequately predict hot tub or flush toilet use among respondents). At the same time, however, the results shown in Table 35 suggest that the presence of such appliances and the performance of water-using behavior are not predictive of water use. Thus, the results in Tables 34 and 35 do not support the indirect linkage posited between socioeconomic factors (through the use of certain appliances and the performance of certain behaviors) and water use.

Tables 36 and 37 examine the effects of adding indicators of city of residence (Table 36) and the presence of appliances and water-using behaviors (Table 37) to the socioeconomic model. The results in Table 36 suggest that adding a variable to take into account the different residence areas (cities) of respondents does not improve the predictive ability of the socioeconomic model (the R^2s are identical in this model to those shown in Table 33) and does not markedly alter the relative importance of different variables within the model. In like manner, the results shown in Table 37 indicate that variables indicating the presence of certain appliances and the performance of certain behaviors add only 3 percent to the predictive ability of the socioeconomic model, and although several of these variables are entered in the stepwise model, the importance of socioeconomic variables remains relatively similar in the two models. As in the original model, then, socioeconomic variables are shown to be important but relatively weak predictors of daily per capita water use.

Table 38 presents the results of the combined model in which all of the previously delineated independent variables are regressed on per capita water use. The results shown in this table largely verify those in previous tables showing the overall explanatory power of the model to be

Table 36

Results of Ordinary Least Squares and Stepwise Regressions of Computed Per Capita Water Use on Selected Socioeconomic Characteristics and City Indicators for Survey Respondents
(N = 744)

Variable Name	Ordinary Least Squares		Stepwise Regression		
	Unstandardized Coefficients	Standardized Coefficients	Order of Entrance	Unstandardized Coefficients	R^2
Intercept	141.06*	0.00	--	---	---
Sex	-4.49	-0.02	--	---	---
Marital Status	14.14*	0.15	2	12.50*	0.05
Persons Per Household	-13.48*	-0.22	1	-13.58*	0.04
Age	-0.50*	-0.09	5	-0.60*	0.09
Education	1.17	0.05	--	---	---
Race: Black	-18.87	-0.05	--	---	---
Race: Hispanic	22.64*	0.10	6	15.73*	0.09
Family Income	1.56	0.04	--	---	---
Housing Type	-1.74	-0.02	--	---	---
Square Feet	0.00	0.01	--	---	---
Occupation	2.14*	0.03	--	---	---
Tenure	35.64	0.13	3	40.21*	0.07
Attitude	-0.91*	-0.06	--	---	---
City Dummy 1	25.83	0.09	4	23.83*	0.08
City Dummy 2	-14.41	-0.05	7	-19.24	0.10
City Dummy 3	3.78	0.01	--	---	---
City Dummy 4	1.38	0.00	--	---	---
City Dummy 5	8.38	0.03	--	---	---
City Dummy 6	-3.94	-0.01	--	---	---
City Dummy 7	5.67	0.02	--	---	---

Adjusted R^2 = 0.08

* Indicates statistical significance at the .05 level.

Table 37

Results of Ordinary Least Squares and Stepwise Regressions of Computed Per Capita Water Use on Selected Socioeconomic Variables and on Variables Indicating Possession of Appliances and Performance of Selected Water–Using Behavior for Survey Respondents
(N = 744)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficients	Standardized Coefficients	Order of Entrance	Unstandardized Coefficients	R^2
Intercept	121.30	0.00	--	---	---
Sex	-8.70	-0.04	--	---	---
Marital Status	16.70*	0.18	3	15.90*	0.09
Persons Per Household	-14.30*	-0.24	1	-14.28*	0.04
Age	-0.38	-0.07	8	-0.41	0.12
Education	1.21	0.05	--	---	---
Race: Black	-9.09	-0.02	--	---	---
Race: Hispanic	25.38*	0.11	5	18.93*	0.11
Family Income	0.74	0.02	--	---	---
Housing Type	-2.90	-0.03	--	---	---
Square Feet	0.00	0.01	--	---	---
Tenure	30.46*	0.11	4	34.17*	0.10
Occupation	2.40	0.03	--	---	---
Attitude	-0.99	-0.06	9	-0.92	0.13
Automatic Dishwasher	2.64	0.01	--	---	---
Washing Machine	33.00*	0.09	6	35.90*	0.12
Bathtub	-37.30*	-0.08	7	-29.94	0.12
Shower	44.57*	0.15	2	49.04*	0.07
Leaky Faucets	11.30	0.04	--	---	---
Flush Toilets	-9.72	-0.01	--	---	---
Hot Tub	-16.17	-0.02	--	---	---
Swimming Pool	-21.90	-0.04	--	---	---
Lawn Sprinklers	5.85	0.02	--	---	---
Home Garden	8.06	0.03	--	---	---
Wash Vehicles	1.55	0.01	--	---	---

Adjusted R^2 = 0.11

* Indicates statistical significance at the .05 level.

Table 38

Results of Ordinary Least Squares and Stepwise Regressions of Computed Per Capita Water Use on Selected Socioeconomic Indicators, Indicators of Use of Selected Appliances and Performance of Selected Water-Using Behavior, and City Indicators for Survey Respondents
(N = 744)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficients	Standardized Coefficients	Order of Entrance	Unstandardized Coefficients	R^2
Intercept	119.85*	0.00	--	---	---
Sex	-7.98	-0.04	--	---	---
Marital Status	17.34*	0.19	3	16.00*	0.09
Persons Per Household	-14.26*	-0.24	1	-14.42*	0.04
Age	-0.36	-0.06	10	-0.40*	0.13
Education	1.09	0.05	--	---	---
Race: Black	-4.56	-0.01	--	---	---
Race: Hispanic	22.69	0.10	7	13.51	0.12
Family Income	0.57	0.02	--	---	---
Housing Type	-2.47	-0.03	--	---	---
Square Feet	0.00	0.02	--	---	---
Occupation	2.21	0.03	--	---	---
Tenure	29.67*	0.10	4	33.30*	0.10
Automatic Dishwasher	2.66	0.01	--	---	---
Washing Machine	34.17*	0.09	6	35.72*	0.12
Bathtub	-37.04*	-0.08	9	-30.92*	0.13
Shower	44.21*	0.15	2	47.02*	0.07
Leaky Faucets	13.05	0.05	11	13.59	0.14
Flush Toilets	-11.04	-0.01	--	---	---
Hot Tub	-13.61	-0.02	--	---	---
Swimming Pool	-23.69	-0.05	--	---	---
Lawn Sprinklers	7.02	0.02	--	---	---
Home Garden	6.83	0.03	--	---	---
Wash Vehicles	2.80	0.01	--	---	---
Attitude	-1.11*	-0.07	8	-1.22*	0.13
City Dummy 1	31.85*	0.11	5	26.20	0.11
City Dummy 2	-5.51	-0.02	12	15.69	0.14
City Dummy 3	10.21	0.03	--	---	---
City Dummy 4	10.29	0.03	--	---	---
City Dummy 5	12.19	0.04	--	---	---
City Dummy 6	3.41	0.01	--	---	---
City Dummy 7	13.67	0.04	--	---	---

Adjusted R^2 = 0.11

* Indicates statistical significance at the .05 level.

small but with several key socioeconomic variables being relatively important. Thus, a weak but significant role for socioeconomic factors is displayed by the models shown in Tables 33-38.

Results Using **Reported** Water Use Rates

As noted in the methodology section, one of the difficulties encountered in obtaining water use data was that many respondents could not readily recall or obtain their records showing water use for previous periods. As a result, the **computed** per capita water use rates were derived and analyzed as shown above. Because such computed rates were derived using average use figures (see Table 28), it can be argued that such procedures would regress the results toward the mean resulting in an apparent reduced ability to predict water use levels that is a result of the procedures used to compute water use rates rather than a reflection of the true effects of socioeconomic variables on water use.

As a means of assessing the extent to which the results obtained (and reported in Tables 33-38) may result from the particular form of the dependent variable used in the analysis, additional analysis was performed using two dependent variables that reflect respondents' direct reporting of water use. One of these dependent variables (the results for which are reported in Table 39) used all respondents who provided an answer to either question 7 or question 10 (these were mutually exclusive response options); that is, who provided data from either their most recent utility bill (question 7) or an estimate from memory (question 10). For these 357 respondents, such reported monthly levels were converted to daily per capita values prior to their use in the regression analysis.

The other alternative dependent variable used (for which the results are shown in Table 40) was derived solely from answers of respondents who used information from their most recent utility bill to report levels of water use (question 7). This information was available for 223 respondents and might be deemed to provide a more accurate reflection of actual water use. Water use data from question 7 were also converted to daily per capita values for use in the analysis.

For each of these two alternative dependent variables, all of the regression models shown in Tables 33-38 were computed. In addition, runs were made in which the models shown in Tables 33-38 were run on these alternative dependent variables but in which the responses for respondents who did not respond to the two questions were assumed to be the same as the mean values for persons from their cities who did provide information on these questions. This provided models in which the total sample of respondents could be employed in the computations.

In general, the results of the analysis of the alternative indicators of water use suggest that the results shown in models 33-38 were not a result of the form of the dependent variable used in the analysis. In all models for the two alternative water-use indicators, the levels of explained variation were little different than those found in using the computed water use variable. Thus, Tables 39 and 40 present results for the two fully specified models using the two alternative water use indicators. An examination of the data in these tables reveals that the two alternative total models explain only 12 percent and 15 percent, respectively, of the variation in water use compared to 11 percent for the computed water use variable model. In addition, although the city indicator (dummy) variables are of greater significance in the two alternative models than in the computed variable models, the results provide general support for the importance of several socioeconomic

Table 39

Results of Ordinary Least Squares and Stepwise Regressions of Reported Per Capita Water Use as Reported by Respondents (Q7 and Q10) on Selected Socioeconomic Indicators, Indicators of Use of Selected Appliances and Performance of Selected Water-Using Behavior and City Indicators for Survey Respondents
(N = 357)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficients	Standardized Coefficients	Order of Entrance	Unstandardized Coefficients	R^2
Intercept	87.74	0.00	--	---	---
Sex	-4.09	-0.01	--	---	---
Marital Status	-2.45	-0.01	--	---	---
Persons Per Household	11.01	0.07	--	---	---
Age	-1.03	-0.07	8	0.14	-1.11
Education	-3.34	-0.05	--	---	---
Race: Black	-1.01	-0.00	--	---	---
Race: Hispanic	-3.03	-0.00	--	---	---
Family Income	10.39	0.12	1	0.05*	12.03
Housing Type	-10.95	-0.05	--	---	---
Square Feet	0.03*	0.13	4	0.11*	0.03
Occupation	10.58	0.06	7	0.13	16.38
Tenure	38.61	0.06	--	---	---
Automatic Dishwasher	11.56	0.02	--	---	---
Washing Machine	-63.18	-0.06	--	---	---
Bathtub	48.60	0.04	--	---	---
Showers	-8.94	-0.01	--	---	---
Leaky Faucets	58.58	0.09	10	0.15	46.85
Flush Toilets	-14.74	-0.00	--	---	---
Hot Tubs	25.52	0.02	--	---	---
Swimming Pool	149.24*	0.12	3	0.10*	171.19
Lawn Sprinkler	91.92*	0.12	5	0.12	72.15
Home Garden	-35.06	-0.06	--	---	---
Wash Vehicle	-43.93	-0.09	9	0.14	-38.11
Attitude	-0.41	-0.01	--	---	---
City Dummy 1	75.85	0.11	--	---	---
City Dummy 2	131.11*	0.20	6	0.13	56.08
City Dummy 3	95.08	0.14	--	---	---
City Dummy 4	108.87*	0.16	--	---	---
City Dummy 5	107.15*	0.13	--	---	---
City Dummy 6	221.91*	0.29	2	0.07*	134.62
City Dummy 7	108.63*	0.15	--	---	---

Adjusted R^2 = 0.12

* Indicates statistical significance at the .05 level.

Table 40

Results of Ordinary Least Squares and Stepwise Regression of Reported Per Capita Water Use as Reported by Respondents from Utility Bills (Q7) on Selected Socioeconomic Indicators, Indicators of Use of Selected Appliances and Performance of Selected Water-Using Behavior and City Indicators for Survey Respondents
(N = 223)

	Ordinary Least Squares		Stepwise Regression		
Variable Name	Unstandardized Coefficients	Standardized Coefficients	Order of Entrance	Unstandardized Coefficients	R^2
Intercept	54.09	0.00	--	---	---
Sex	-28.66	-0.05	--	---	---
Marital Status	-10.50	-0.04	--	---	---
Persons Per Household	-1.99*	-0.01	5	-2.38*	0.19
Age	-2.55	-0.17	--	---	---
Education	-0.58	-0.10	--	---	---
Race: Black	37.96	0.03	--	---	---
Race: Hispanic	43.87	0.07	Eliminated: Step 6	---	---
Family Income	7.26	0.08	--	---	---
Housing Type	-6.40	-0.02	4	0.03*	0.17
Square Feet	0.03	0.13	--	---	---
Occupation	14.00	0.08	8	87.80	0.20
Tenure	51.33	0.07	--	---	---
Automatic Dishwasher	32.95	0.06	--	---	---
Washing Machine	19.48	0.01	--	---	---
Bathtub	30.78	0.02	--	---	---
Showers	7.15	-0.01	--	---	---
Leaky Faucets	58.37	0.08	--	---	---
Flush Toilets	8.18	0.00	--	---	---
Hot Tubs	312.60*	0.22	1	350.17*	0.07
Swimming Pool	43.68	0.05	--	---	---
Lawn Sprinkler	-59.77	-0.10	--	---	---
Home Garden	-67.75*	-0.13	--	---	---
Attitude	-0.10	-0.00	--	---	---
City Dummy 1	81.14	0.10	--	---	---
City Dummy 2	142.07*	0.21	7	90.97*	0.19
City Dummy 3	157.30*	0.21	9	80.67	0.21
City Dummy 4	65.74	0.08	--	---	---
City Dummy 5	87.50	0.08	--	---	---
City Dummy 6	308.24*	0.41	2	241.03*	0.14
City Dummy 7	115.98	0.17	--	---	---

Adjusted R^2 = 0.15

* Indicates statistical significance at the .05 level.

variables within these relatively weak predictive models. Overall, then, the results of the analysis of alternative models adds little to our ability to predict per capita water use differences among respondents.

The results of the primary data analysis provide general support for the major premise of the study--that socioeconomic and sociodemographic variables do affect levels of water use. At the same, time, however, the results suggest that such variables, at least as measured in the primary data analysis effort, explain only a small proportion of the variation in daily per capita water use. Despite the low percent of variation explained by these variables, the results are generally consistent with those from the secondary data analysis in that variables associated with minority status and those associated with socioeconomic status do affect water use with indicators of economic resources being related to increased water use and minority status with reduced water use. Overall, then, although the results provide only limited support for the predictive capabilities of socioeconomic and sociodemographic models in explaining water use at the individual level, the nature of the relationships found and the significance of such variables in the models are generally supportive of the importance of such variables in projecting water use and water demand.

Section IV

Projection of Water Use

The primary goal of the projection analysis is to determine if the conclusion of key social and demographic variables in water use projection models improves the accuracy of water use projections, compared to projections based on the use of per capita indicators only and, if so, what implications would the use of these variables have on water use projections for future periods. To accomplish this goal, an analysis was conducted which compared projected water consumption using different techniques with actual water consumption. This was done by obtaining actual 1970 residential water use data from the Texas Water Development Board, projecting 1980 water use both with and without key social and demographic variables, and then comparing these two types of projections to actual 1980 water use.

Since most water use projections involve the use of data for a known time period to project use for future periods, the use of 1970 data as the basis for 1980 projections allowed us to simulate the procedures likely to be used in projection projects. In other words, a comparison was made of the traditional per capita based methods with projection models using key social and demographic variables. The per capita methods consist of the simple multiplication of per capita use by the projected total population to determine projected water use for that future year. When projections are made using key social and demographic variables, the per capita use for population subgroups with specific characteristics (e.g., households with specific age, race/ethnicity, and household forms) is determined and then this is multiplied by the number of households with that characteristic in the population in the year for which the projections are being made.

The average Texas household consumed 463.9 gallons of water per day for residential purposes in 1970 and consisted of 3.13 persons. Thus the per capita daily consumption of water amounted to 148.2 gallons. Overall, more than 1.6 billion gallons of water were being used daily for residential purposes in the state of Texas in 1970 (Table 41).

The Texas Department of Water Resources has noted that historically the per household daily consumption of water has increased by about 4 gallons per decade (Texas Department of Water Resources, 1984). Thus, in making the per capita projections to 1980, it was assumed that residential water consumption would increase by 4 gallons per household per day between 1970 and 1980. Consequently, when making the per capita projections to 1980, it was assumed that the average daily household consumption of water would be 467.9 gallons in 1980. With a total population in 1980 of over 14 million people (about 4.9 million households), it would then be projected that the total water consumed for residential purposes in 1980 would be about 2.3 billion gallons per day (Table 41). This is how water use projections are typically made, and is how projections for 1980 water use would most likely have been made for planning purposes in 1970.

In comparing the projections with actual water consumption, it is necessary to have data not only for the average household, but also for households with different social and demographic characteristics. The only comparable data source which met those needs was our survey of water consumption by Texas households. Thus, although the sample members are clearly not presumed to be representative of the total population (see pg. 60), data on them provided the only data available for projecting the effects of demographic characteristics of water uses. Survey data revealed that the average household consumed 376.3 gallons of water per day for residential purposes (Table 41). With over 4.9 million households in the state, this resulted in an estimate that less than 1.9 billion gallons of water would be consumed per day for residential purposes in 1980. Table 41 shows that this figure differs from the projected 1980 water use by 91.6 gallons per household per day, or by 452 million gallons per day for the State as a whole.

When projecting water consumption using social and demographic characteristics, it was first necessary to determine average water use for household groups with different characteristics. As noted earlier, the 1986 household water use survey provided the only available data to determine daily water use for households with different social and demographic characteristics. For purposes of this report, three social and demographic characteristics were used for the projection models. These include household size, age of the householder, and ethnicity (Hispanic vs. non-Hispanic). Results of the analysis of survey data during fiscal year 1986 showed that each of these variables was related to household water consumption. Projections were made by using each of these social and demographic variables individually. In addition, both two-way (e.g., household size and age) and three-way (e.g., household size, age, and ethnicity) combinations of characteristics were also used to project water use. In order to have a sufficiently large number of respondents with each characteristic to estimate water use, it was possible to only dichotomize each social and demographic variable. Household size was categorized into small (1 or 2 person) households and large (3 or more persons) households. Age of the householder (e.g. the household head) was divided into young (44 or less) and old (45 or more), while ethnicity was dichotomized into Hispanic and non-Hispanic.

Table 41

Actual 1970 and 1980 Water Use, 1980 Projections Based on the Per Capita Method and Differences Between Actual and Projected Use

	Daily Household Water Use (gallons)	Total Water Used Daily (1,000 gallons)
1970 Actual Water Use	463.9	1,659,477
1980 Projected Water Use	467.9	2,309,048
1980 Actual Water Use	376.3	1,857,048
Difference Between Actual and Projected	91.6	452,092

As shown in Table 42, persons residing in small households use nearly as much water as those living in large households (346.8 gallons compared to 400.9 gallons per day). On a per capita basis, this means that persons living in small households use about twice as much water as persons living in large households. This difference probably occurs because water utilizing appliances such as dishwashers and washing machines can be used more efficiently in homes with larger numbers of people, and lawn care and similar activities require the same amount of water regardless of how many persons live in the home. It was also found that households with a younger householder use more water than households with an older householder (402.0 to 354.5 gallons). Households with a young householder tended to be larger, and consequently the per capita use of water in these homes was less than households with an older householder. Finally, Hispanic households use more water on the average than non-Hispanic households (406.8 to 364.0 gallons). Again, the typical Hispanic household is larger than the typical non-Hispanic household, and thus their per capita use of water is lower. This is probably because, on the average, non-Hispanics have higher incomes, which the analysis of survey data indicate is related to increased water use. Table 42 also shows average water consumption for households categorized by combinations of these 3 variables.

Table 43 presents information from the 1980 census of the population showing the proportion of the total State's households having the various combinations of social and demographic characteristics. This table also shows the total amount of water consumed by different population groups, which is calculated by multiplying the average daily household water use for that group of people (from Table 42) by the total number of households with that characteristic in the state. By summing the amount of water

Table 42

Daily Household Water Use for Households With Different Characteristics Based on 1986 Household Water Use Survey

Population Group	Daily Household Water Use (gallons)
Household Size	
1 or 2 persons (small)	346.8
3 or more persons (large)	400.9
Age of Householder	
44 or less (young)	402.0
45 or more (old)	354.5
Ethnicity	
Hispanic	406.8
Non-Hispanic	364.0
Household Size and Age of Householder	
Small and young	385.8
Small and old	334.7
Large and young	406.5
Large and old	390.4
Household Size and Ethnicity	
Small and Hispanic	516.7
Small and non-Hispanic	311.5
Large and Hispanic	366.5
Large and non-Hispanic	422.9
Household Size, Age, and Ethnicity	
Small, young and Hispanic	915.0
Small, young and non-Hispanic	216.1
Small, old and Hispanic	317.5
Small, old and non-Hispanic	337.7
Large, young and Hispanic	353.2
Large, young and non-Hispanic	438.3
Large, old and Hispanic	388.9
Large, old and non-Hispanic	391.5

Table 43

Projected Total Water Use in 1980 Based on Various Social and Demographic Characteristics

Social and Demographic Variables	Percent of Total Households in State	Projected Total Water Used Daily (1,000 gallons)
Household Size		
1 or 2 persons (small)	52.4	896,808
3 or more persons (large)	47.6	941,742
Total	100.0	1,838,550
Age of Householder		
44 or less (young)	53.2	1,055,423
45 or more (old)	46.8	818,749
Total	100.0	1,874,172
Ethnicity		
Hispanic	15.5	311,173
Non-Hispanic	84.5	1,517,913
Total	100.0	1,829,086
Household Size and Age of Householder		
Small and young	20.7	394,114
Small and old	31.7	523,605
Large and young	32.5	651,978
Large and old	15.1	290,921
Total	100.0	1,860,618

Table 43 (continued)

Social and Demographic Variables	Percent of Total Households in State	Projected Total Water Used Daily (1,000 gallons)
Household Size and Ethnicity		
Small and Hispanic	4.7	119,846
Small and non-Hispanic	47.7	733,272
Large and Hispanic	10.9	197,147
Large and non-Hispanic	36.7	765,936
Total	100.0	1,816,201
Household Size, Age and Ethnicity		
Small, young and Hispanic	2.2	99,342
Small, young and non-Hispanic	18.5	197,295
Small, old and Hispanic	2.5	39,172
Small, old and non-Hispanic	29.2	486,634
Large, young and Hispanic	7.3	127,243
Large, young and non-Hispanic	25.2	545,703
Large, old and Hispanic	3.5	67,173
Large, old and non-Hispanic	11.6	224,119
Total	100.0	1,786,681

consumed daily by each category of people, a number representing the total populations projected water use was obtained.

An examination of the projected total daily water use in Table 43 shows that these figures range from about 1.8 billion gallons per day to 1.9 billion gallons per day. All of these projected water use figures are similar to actual 1980 water use and substantially closer to actual water use than those projections using per capita methods only.

Table 44 presents a summary of the results of the various water use projections models. This table shows that while the projections from the per capita method differed from actual 1980 water use by more than 400 million gallons per day, the results obtained from projection models, using social and demographic variables were much closer to actual use. Projections of 1980 water consumption using social and demographic variables differed from actual water consumption by a range of 3.5 million gallons per day to 70.4 million gallons per day. The model using social and demographic variables that provided the most accurate projection of actual water use was one that considered household size and the age of the householder. These results thus indicate that the use of social and demographic variables provides projections that are closer to actual water use than the per capita method provides.

Comparison of Projections for Places in the State

In this section, a comparison will be made of the accuracy of the results of the projection models for places (cities) in the state. This will be accomplished by comparing the amount of error between actual and projected water use for the different projection models for places in the State. Three measures of the amount of error will be used including the mean percentage error (MPE), the mean absolute percentage error (MAPE), and

Table 44

Summary of the Results for Various Water Use Projection Models for Projections of 1980 Water Use in Texas

Type of Projection Model	Projected Total Daily Water Use (1,000 gal.)	Difference From Actual Use (1,000 gal.)	Improvement From Per Capita Projection (1,000 gal.)
Per Capita Method	2,309,048	452,092	---
Using Social and Demographic Variables			
Household size only	1,838,550	18,498	433,633
Age of householder only	1,874,172	-17,124	434,968
Ethnicity only	1,829,086	27,962	424,130
Household size and age	1,860,618	-3,570	448,522
Household size and ethnicity	1,816,201	40,847	411,245
Household size, age and ethnicity	1,786,681	70,367	381,725

(that is, whether it is positive or negative) and the population size of place into account in computing the rates of error. The mean percent error (MPE) is a simple mean of values in which negative and positive values cancel one another. The mean absolute percent error (MAPE) measure's use of absolute values does not allow positive and negative errors to cancel one another and so provides a measure in which overall accuracy is the focus, and the mean percent absolute difference (MPAD) measure (also referred to as the weighted mean absolute percentage error) controls for both the effects of different types of errors (positive or negative) and the effects of the population size of the projection area. Whereas the mean absolute percent error gives all areas equal weight (such that a 3 percent error for a city of 1,000 affects the overall value by the same extent as a 3 percent error for a city of 1,000,000), the mean percent absolute difference measure weights all areas by their population size. The formulas for their measures are as follows:

$$\text{Mean Percent Error (MPE)} = \frac{\sum_{i=1}^{n} \frac{(\text{projected water use value} - \text{actual water use})}{\text{actual water use}}}{n} \times 100$$

$$\text{Mean Absolute Percent Error (MAPE)} = \frac{\sum_{i=1}^{n} \left| \frac{\text{projected water use value} - \text{actual water use}}{\text{actual water use}} \right|}{n} \times 100$$

$$\text{Mean Percent Absolute Difference (MPAD)} = \frac{\sum_{i=1}^{n} \left| \text{projected water use value} - \text{actual water use} \right|}{\sum_{i=1}^{n} \text{1980 census population}} \times 100$$

Where n = number of geographic units (counties, places, etc.)

Comparisons of the amount of error are shown for all places in the State, for places (cities) categorized by size, and for places categorized by the level of population change between 1970 and 1980. In addition, data were presented showing the number of cities where projected water use was either higher or lower than actual water use. Such procedures are those commonly employed to measure the accuracy of demographic projections.

The procedures used in this section are identical to those used in the previous section, except that projected and actual water use are computed separately for each place. Data on actual water use were available for 411 Texas places in 1970. These 411 cities are used throughout this analysis.

Table 45 presents data which compare the amount of error between actual water use and projected water use in 1980 using the various projection models for all Texas cities. An examination of this table makes it apparent that the projections from all of the projection models using social and demographic variables have substantially less error than those made using the per capita method. For the MPE measure, the per capita method has an error rate of 10.41. In comparison, the projection models using social and demographic variables have an error rate (MPE) ranging from 0.22 to -2.82. The use of social and demographic variables provided similar improvement over the per capita method for the MAPE and MPAD measures. The social and demographic model with the least amount of error was the model that considered the age of the householder only for the MPE and MAPE measures, while the model considering household size and the age of the householder had the least amount of error for the MPAD measure. For all three measures, the social and demographic model with the greatest error was the model that considered all three variables (Table 45).

Table 45

A Comparison of the Amount of Error Between Actual and Projected Water Use Using Different Projection Models for All Cities
(N = 411)

Type of Projection Model	MPE	MAPE	MPAD
Per Capita Method	10.41	30.06	0.039
Using Social and Demographic Variables:			
Household size	-0.87	1.16	0.003
Age of householder	0.22	0.89	0.003
Ethnicity	-1.47	2.40	0.003
Houshold size and age	-0.46	1.42	0.001
Household size and ethnicity	-2.15	3.02	0.006
Household size, age and ethnicity	-2.82	3.23	0.010

The data in Table 46 provide a comparison of the amount of error between actual and projected water use for Texas cities of different sizes. Again it is apparent that the projection models using social and demographic variables are substantially better than the model based on per capita methods, regardless of the size of the city. Further, Table 46 shows that the accuracy of the projection models vary by the size of the city. Regardless of the social and demographic model being utilized, it was generally found that there was less error in the medium-sized communities, and that the amount of error increased as the communities being examined became progressively larger or smaller.

Another comparison was made to determine if there were differences in the accuracy of the water use projection models for communities with different patterns of population change between 1970 and 1980. Because it is more difficult to project future population levels in areas where the population is changing rapidly, it is also more difficult to project water use for such areas. The results of this analysis are shown in Table 47. The data in Table 47 further point to the superiority of the projection models made using social and demographic variables over the per capita method apparent. A further examination of Table 47 show that it is difficult to determine if the projection models are more accurate for communities with different patterns of population change. While Table 47 shows that some social and demographic models are obviously superior to others, the models do not appear to be consistently more accurate for cities with specific rates of population change.

Finally, an analysis was conducted to determine if the various projection techniques tended to under or over estimate water use for cities. An overview of Table 48 shows that generally the procedure tended

Table 46

A Comparison of the Amount of Error Between Actual and Projected Water Use Using Different Projection Models for Cities by Size
(N = 411)

Population of City	N	Per Capita Method			Household Size			Age of Householder			Ethnicity			Household Size and Age of Householder		
		MPE	MAPE	MPAD	MPE	MAPE	MPAD	MPE	MAPE	MPAD	MPE	MAPE	MPAD	MPE	MAPE	MPAD
< 1,000	11	-4.22	31.43	0.11	-1.46	1.63	0.13	-0.38	0.57	0.04	-1.48	2.17	0.15	-1.47	1.61	0.13
1,000- 2,500	43	16.71	35.29	0.31	-1.42	1.51	0.03	-0.39	0.65	0.01	-1.74	2.21	0.04	-1.44	1.60	0.04
2,500-10,000	209	11.29	32.42	0.04	-0.88	1.21	0.01	0.05	0.91	0.00	-1.34	2.36	0.01	-0.62	1.54	0.01
10,000-25,000	96	5.75	25.06	0.06	-0.61	0.91	0.01	0.52	0.91	0.01	-1.58	2.48	0.02	-0.02	1.25	0.00
25,000-50,000	37	11.12	23.20	0.37	-0.54	0.95	0.02	0.79	0.92	0.02	-1.33	2.81	0.04	0.31	1.06	0.01
50,000+	15	18.82	30.07	1.37	-1.08	1.24	0.10	1.42	1.42	0.10	-1.47	2.23	0.08	0.65	1.05	0.04

Population of City	Household Size and Ethnicity			Household Size, Age of Householder and Ethnicity		
	MPE	MAPE	MPAD	MPE	MAPE	MPAD
< 1,000	-3.36	3.97	0.31	-3.52	3.56	0.33
1,000- 2,500	-3.40	3.81	0.08	-3.30	3.33	0.08
2,500-10,000	-2.13	3.11	0.01	-2.63	3.07	0.01
10,000-25,000	-1.77	2.50	0.02	-2.62	3.04	0.03
25,000-50,000	-1.35	2.70	0.04	-2.87	3.64	0.08
50,000 +	-2.30	2.99	0.18	-4.65	5.30	0.35

Table 47

A Comparison of the Amount of Error Between Actual and Projected Water Use Using Different Projection Models for Cities by Amount of Population Change From 1970 to 1980
(N = 411)

Percent Population Change 1970-1980	N	Per Capita Method			Household Size			Age of Householder			Ethnicity			Household Size and Age of Householder		
		MPE	MAPE	MPAD	MPE	MAPE	MPAD	MPE	MAPE	MPAD	MPE	MAPE	MPAD	MPE	MAPE	MPAD
< -10.1	15	5.66	50.01	0.45	-0.86	0.98	0.06	0.67	1.06	0.05	-2.24	2.50	0.15	-0.07	1.27	0.00
-10.1 - 0.0	45	9.01	30.44	0.25	-0.97	1.11	0.03	0.31	0.84	0.01	-1.95	2.24	0.05	-0.46	1.25	0.01
0.0 - 10.0	103	6.26	25.25	0.12	-1.26	1.36	0.02	-0.25	0.67	0.01	-1.73	2.22	0.02	-1.16	1.44	0.01
10.0 - 20.0	84	11.43	30.24	0.20	-1.07	1.34	0.01	-0.15	0.89	0.01	-1.51	2.41	0.02	-0.93	1.63	0.00
20.0 - 30.0	62	13.14	28.74	0.25	-0.89	1.13	0.02	0.17	0.81	0.02	-1.36	2.35	0.02	-0.50	1.25	0.01
30.0 - 40.0	25	34.45	47.47	1.68	-0.47	1.25	0.02	0.30	0.69	0.05	0.22	2.82	0.02	-0.04	1.30	0.04
40.0 - 50.0	22	4.88	29.37	0.10	-0.46	0.85	0.00	.0.82	1.16	0.07	-1.52	2.43	0.07	0.35	1.45	0.06
50+	55	7.26	26.89	0.15	-0.06	0.74	0.00	1.24	1.38	0.03	-1.16	2.70	0.03	1.01	1.47	0.03

Percent Population Change 1970-1980	Household Size and Ethnicity			Household Size, Age of Householder and Ethnicity		
	MPE	MAPE	MPAD	MPE	MAPE	MPAD
< 10.1	-2.52	2.87	0.17	-3.73	3.77	0.26
-10.1 - 0.0	-2.58	2.95	0.08	-3.29	3.34	0.11
0.0 - 10.0	-2.99	3.45	0.04	-3.23	3.31	0.06
10.0 - 20.0	-2.60	3.43	0.03	-2.89	3.23	0.04
20.0 - 30.0	-2.19	2.90	0.03	-2.85	3.26	0.07
30.0 - 40.0	-0.63	3.23	0.01	-1.54	3.42	0.09
40.0 - 50.0	-1.32	2.23	0.02	-2.55	2.92	0.10
50+	-0.37	2.05	0.01	-1.95	2.89	0.05

to under rather than over estimate water use. Regardless of the circumstances, however, it is again apparent that the social and demographic models are superior to the per capita method.

In sum, in this section it has been shown that projection models using social and demographic variables are more accurate than projections made using the per capita method alone. It also appears that water use projections are most accurate for medium-sized cities, and are least accurate for the very large and very small cities. Variations in rates of population change in Texas cities do not appear to effect the accuracy of water use projections.

Table 48

A Comparison of Water Use Projections Above or Below Actual Water Use Using Different Projection Models
(N = 411)

Actual	N	MPE	MAPE	MPAD
		- - Per Capita Method- -		
Above	201	11.03	11.03	0.55
Below	210	-5.27	5.27	0.03
		- - Households Size - -		
Above	99	0.58	0.58	0.01
Below	312	-1.48	1.48	0.01
		- - Age of Householder - -		
Above	244	6.12	6.12	0.03
Below	167	-0.11	0.11	0.00
		- - Ethnicity - -		
Above	66	2.59	2.59	0.04
Below	345	-2.22	2.22	0.01
		Household Size and Age - - of Householder - -		
Above	167	3.44	3.44	0.02
Below	244	-0.44	0.44	0.00
		Household Size - - and Ethnicity - -		
Above	84	2.35	2.35	0.03
Below	327	-3.34	3.34	0.01
		Household Size, Age of Householder and Ethnicity		
Above	55	1.72	1.72	0.03
Below	356	-5.57	5.57	0.02

Section V

Summary, Conclusions and Recommendations for the Use of Sociodemographic Variables in Projections of Water Demand

The study reported here presents the results of a study of the effects of sociodemographic and socioeconomic variables on water use and on the implications of these effects for projections of water demand. The analysis examines the effects of such variables on water use using both secondary and primary data.

The study is clearly limited in a number of regards. It examines data for only a single period of time and for a limited number of places. It examines the effects of such factors on only daily per capita water use rather than on several indicators of water consumption and demand. Its analysis included only some of the many sociodemographic and socioeconomic variables that may affect water use, and its survey analysis is based on data for residents in only eight locations in the State rather than on a state-wide sample of residents. Clearly the use of random sample surveys of the entire state population, secondary analysis examining multiple time periods and analyses using longitudinal as well as cross-sectional analysis techniques as well as studies that attempt to measure additional social, cultural, attitudinal and other factors should be completed. This analysis was thus clearly a limited analysis.

Despite such limitations, however, the results of the secondary analysis suggest that sociodemographic and socioeconomic variables do affect levels of average daily per capita water use and may be important in predicting water demand. They suggest that characteristics of cities such as their total number of housing units, the percent of their population that is made up of minority group members, the age of their housing stock, the general level of urban development in an area, and the socioeconomic resources of a population do affect per capita water use. They further suggest that there is substantial regional variation in the effects of such factors and that additional factors, not examined in this analysis, clearly affect levels of per capita water use and must be given additional attention. The results of the analysis of the primary data support the findings from the secondary data analysis and the premise that socioeconomic and sociodemographic factors are of significance for understanding variation in water use. In addition, the results of the projection analysis suggest that the use of social and demographic variables allows a substantial improvement to be made in the accuracy of water use projections.

The findings of the analysis thus definitively address the two basic questions underlying the study. They show that demographic factors do affect water use and that their inclusion in projections of water use are likely to increase the accuracy of such projections. The results suggest that planners and others involved in the assessment of future levels of water use should include demographic characteristics in their projections. The results clearly suggest that the inclusion of demographic variables would have increased the accuracy of past projections and that their inclusion is likely to be of even greater importance in the future due to the growing diversity in the Texas population.

During the next few decades, the Texas population is expected to become increasingly diverse socially and demographically. Consequently, the need to utilize social and demographic variables in water use projections will become greater. For example, the data in Table 49 show projections of the size and structure of the Texas population in the year 2000. These projections were obtained from the Texas Water Development

Board, which provides both a high series and a low series projection. Household size projections were obtained from the U.S. Census Bureau, while projections of the age and race/ethnicity of the householders were obtained from the Texas Department of Health.

The high series of Texas population projections show that the number of people in the State is expected to increase by 50.0 percent between 1980 and 2000. In comparsion, the low series projects a population increase of 37.9 percent (Table 49). Obviously, the amount of water consumed in the state will increase substantially under either projection because more people will live in the state. However, the amount of water consumed per capita will also likely increase because of the increasing diversity of the population's characteristics. For example, the continuing trend toward smaller households should affect total water use. Table 49 shows that the average household in the State is expected to decline from 2.81 persons in 1980 to 2.54 in 2000. This means that the number of housholds in the state is expected to increase by 56.6 percent (low series) to 70.3 percent (high series).

The composition of the State's households is also expected to change extensively between 1980 and 2000. As shown in Table 49, the proportion of people living in small households is expected to rise from 52.4 percent in 1980 to 58.0 in 2000. Further, because of the maturing of the baby boom generation, the proportion of households headed by an older householder is expected to increase from 46.8 to 51.9 percent. Finally, because the Hispanic population is growing so rapidly, they are expected to comprise an increasingly larger share of the State's households (from 15.5 percent in 1980 to 22.7 percent in 2000). Since each of these changes will have a major effect on the amount of residential water consumed in the state, it

Table 49

Total Population, Number of Households, and Characteristics of the Population in Texas for 1980 and Projections for 2000

		2000	
	1980	High Series	Low Series
Total Population	14,229,191	21,345,411	19,623,684
Number of Households	4,935,020	8,403,705	7,725,860
Percent of Households:			
Household Size			
1 or 2 persons (small)	52.4	58.0	58.0
3 or more persons (large)	47.6	42.0	42.0
Average household size	2.81	2.54	2.54
Ethnicity			
Hispanic	15.5	22.7	22.7
non-Hispanic	84.5	77.3	77.3
Age of Householder			
44 or less (young)	53.2	48.1	48.1
45 or more (old)	46.8	51.9	51.9

is important that they be considered in water use projection models. The diversity within Texas further suggests that planners and leaders must consider the unique characteristics and varying patterns of change of the population in their own area of the State. Using State or National population patterns could lead to substantial error when applied to an individual community.

In sum, then, the research completed on this project during the past two years has both established the significance of sociodemographic factors for explaining water use and demonstrated that the use of information on such factors in water use projections can improve the accuracy of these projections. Clearly, additional research involving a larger body of interviews with representative samples of residents from different areas of the nation and for alternative periods of time must be completed before the applicability and utility of such information for water use planning is adequately established. In addition, it is evident that a consideration of a wider range of social, psychological and other socioeconomic and sociodemographic factors, as well as water use experiences, should be examined as they affect water use among different socioeconomic and demographic groups. The results of this research are sufficiently clear, however, to suggest that further analysis of the effects of demographic and social factors on water use and the inclusion of such factors in water use projection models should be of increasing concern to those involved in water use planning.

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Appendix

Survey
Questionnaire

HOUSEHOLD WATER USE SURVEY

Questionnaire Number: ____________________

Respondent:

	Call 1	Call 2	Call 3
Interviewer	______	______	______
Date	______	______	______
Call Back Time	______	______	______
Poor Time	______	______	______
Busy Line	______	______	______
No Answer	______	______	______
Refusal	______	______	______
Invalid Number	______	______	______

INTERVIEW:

Start Time: ______________

Completion Time: ______________

Number of Minutes: ______________

HOUSEHOLD WATER USE QUESTIONNAIRE

Hello. My name is _______________, and I am calling from Texas A&M University in College Station. We are talking to persons like you to determine the ways you use water in your daily life and your views about water use and conservation. This information will be very important as plans are made for the future construction and management of water facilities. Is this a convenient time to talk to you?

(INTERVIEWER: IF NOT, ARRANGE A TIME TO CALL BACK)

Your opinions are important to us. However, the information you give us will not be identified with you in any way. Your responses will be kept completely confidential and anonymous.

1. Do you pay your own water bills or are they included as part of your rent payment?

    (1) Pay own water bills **(Proceed with survey)**
    (2) Do not pay own water bills **(Terminate survey)**

ATTITUDES AND OPINIONS

2. To begin with, I would like to ask you several questions about your views concerning water. I am going to read several statements that people sometimes make about water. For each statement I read, please tell me if you strongly agree, agree, neither agree nor disagree, disagree or strongly disagree with the statement. **(INTERVIEWER: CIRCLE RESPONSE)**

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
People should have the right to use as much water as they wish.	1	2	3	4	5
The depletion of groundwater resources (that is, water that is obtained from wells) is a major problem in Texas.	1	2	3	4	5
Most families use more water than they need.	1	2	3	4	5
The government should place restrictions on how much water a family can use.	1	2	3	4	5
The water supply in your area is sufficient to meet the needs of the community for many years to come.	1	2	3	4	5
Your community will never face the problem of an inadequate water supply.	1	2	3	4	5
The cost of water in your area is relatively low.	1	2	3	4	5
It is important that lawns be kept green and healthy, even if it means using a lot of water.	1	2	3	4	5

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
There will always be enough water in Texas to meet the needs of the people.	1	2	3	4	5
If a community has a water shortage problem, mandatory rationing should be enforced.	1	2	3	4	5
Water pollution is a serious problem in Texas.	1	2	3	4	5
Water pollution is a serious problem in your area.	1	2	3	4	5
During water shortages, the watering of lawns should be restricted.	1	2	3	4	5
Today, it costs more to fix a leaky faucet than it is worth in water savings.	1	2	3	4	5
It would be difficult to reduce the amount of water used in your household.	1	2	3	4	5
Removing salt from ocean water is an effective way to deal with water shortage problems.	1	2	3	4	5
Waste water can be effectively treated so that it is safe for household use.	1	2	3	4	5
Sewage water that is treated to be safe for human consumption is an acceptable source of drinking water for you and your family.	1	2	3	4	5
A lack of water will restrict population growth in Texas in the future.	1	2	3	4	5
Texas should import water from other states in order to meet its water needs.	1	2	3	4	5

3. If the cost of water in this area was to double within the next year, by what percent would you attempt to cut back on the amount of water that your household uses?

__________ percent **(INTERVIEWER: IF THEY WOULD NOT DECREASE, BUT WOULD CONTINUE TO USE THE SAME AMOUNT, PLEASE GO TO QUESTION 5)**

4. What are some of the things you would do to reduce the amount of water that your household uses? **(INTERVIEWER: LIST RESPONSES)**

____

____

APPLIANCES AND WATER USE

5. Next, we would like to ask about the appliances you have and the amount of water that you use. Do you have the stub from your last monthly water bill?

   (1) Yes **(Allow person a minute or two to get it; ask questions 6, 7, 8 and 9, then skip questions 10, 11 and 12)**
   (2) No **(Skip to question 10)**

* * * * * * * * * * * *

6. What is the billing period covered by this statement? (e.g., 1/10/86 - 2/9/86)

____

7. According to your stub, how much water did you use during this period?
____________________ gallons **(INTERVIEWER: HAVE RESPONDENT CHECK UNITS IN WHICH THE AMOUNT OF WATER USED IS MEASURED. E.G., 100s OF GALLONS)**

8. What is the name of the utility company your bill was sent from?

____ name of utility

9. How much was your water bill for this billing period?

____________________ dollars **(SKIP TO QUESTION 13)**

* * * * * * * * * * * *

10. What would you estimate to be the number of gallons of water you used last month?

__________________ gallons

11. How much would you estimate your water bill was for last month?

__________________ dollars

12. What is the name of the utility company your bill was sent from?

____ name of utility

* * * * * * * * * * * *

13. On the average, how many meals per day are eaten at home in your household?

__________________ meals per day

14. What is <u>the average number</u> of persons eating each meal?

__________________ persons

15. Which of the following best describes the home in which you currently live? Is it a: **(INTERVIEWER: READ CATEGORIES AND CIRCLE RESPONSE)**

(1) Detached single-family home
(2) Townhouse or condominium
(3) Duplex or fourplex
(4) Apartment
(5) Mobile home
(6) Other (please specify)

16. How large (in square feet) is the home where you currently live?

__________________ square feet

17. Do you own or rent the home in which you currently live? **(INTERVIEWER: CIRCLE RESPONSE)**

(1) Own
(2) Rent

18. Do you have an automatic dishwasher in your home?

(1) Yes **(ask part a)**
(2) No **(ask parts b and c)**

a. How many times would you estimate that you run your dishwasher in a typical week?

__________________ number/week

b. How many times a day do you hand wash dishes?

__________________ number/day

c. Do you: **(INTERVIEWER: READ CATEGORIES AND CIRCLE RESPONSE)**

(1) Rinse each dish as you wash it
(2) Rinse them all at once

19. Do you have a washing machine in your home?

(1) Yes **(ask part a)**
(2) No **(go to question 20)**

a. How many loads of clothes do you typically wash per week?

__________________ number/week

20. Do you have a bath tub in your home?

(1) Yes **(ask parts a and b)**
(2) No **(go to question 21)**

a. Please estimate how many tub baths are taken in your home each week?

__________________ number/week

b. Please estimate how much water is used in the average tub bath in your home. That is, is the tub: **(INTERVIEWER: READ CATEGORIES AND CIRCLE RESPONSE)**

(1) Less than one-fourth full
(2) One-fourth to one-half full
(3) One-half to three-fourths full
(4) Over three-fourths full

21. Do you have a shower in your home?

(1) Yes **(ask parts a, b and c)**
(2) No **(go to question 22)**

a. Please estimate how many showers are taken in your home each week?

__________________ number/week

b. Please estimate the length of the average shower taken in your home?

__________________ minutes

c. Do you have a flow restrictor or water-saver showerhead?

(1) Yes
(2) No

22. Considering <u>all</u> of the faucets inside and outside your home (including showerheads, bathtubs, sink faucets, etc.), how many of these faucets have a leak at this time?

____________________ faucets leak

23. Do you have flush toilets in your home?

(1) Yes **(ask parts a and b)**
(2) No **(go to question 24)**

a. Please estimate the average number of flushes per day in your home:

__________________ number/day

b. Do you have any watersaving devices in your tank or do you have a special watersaving toilet tank?

(1) Yes
(2) No

24. Do you have a hot tub in your home?

(1) Yes **(ask parts a and b)**
(2) No **(go to question 25)**

a. During what months do you use your hot tub?

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b. Please estimate the average number of gallons of water you add to your hot tub during each of these months:

__________________ gallons/month

25. Do you have a swimming pool at your residence?

(1) Yes **(ask parts a, b and c)**
(2) No **(go to question 26)**

a. During what months do you use your swimming pool? **(INTERVIEWER: CIRCLE MONTHS POOL IS USED)**

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b. Please estimate the average number of gallons of water you add to your swimming pool during each of these months.

__________________ gallons/months

c. Do you usually keep your swimming pool covered throughout the year?

(1) Yes **(go to question 26)**
(2) No **(ask part d)**

d. During what months is your pool usually covered? **(INTERVIEWER: CIRCLE COVERED MONTHS)**

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26. Do you have an automatic lawn sprinkling system or do you hand water your yard?

(1) Automatic sprinkling system **(ask parts a, b, c and d)**
(2) Hand water yard **(ask parts a, b, c, and d)**
(3) No yard or don't water it **(go to question 27)**

a. How large is you lot?

____________________acres; or ____________ ft. by ___________ ft.

b. During which months do you water your yard? **(INTERVIEWER: CIRCLE MONTHS)**

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c. What is the average number of times you water your yard per month during this period?

__________________ number/month

d. On the average, how long is each watering cycle?

__________________ hrs. __________________ min.

27. Do you have a home garden that you water?

(1) Yes **(ask parts a, b, c and d)**
(2) No **(go to question 28)**

a. How large is your garden plot?

__________________ acres; or ______________ ft. by ____________ ft.

b. **During which months do you water your garden plot? (INTERVIEWER: CIRCLE MONTHS)**

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c. **What is the average number of times you water your garden plot per month during this period?**

__________________ number/month

d. On the average, how long is each watering cycle?

__________________ hrs. __________________ min.

28. Do you wash your car or other vehicle at home?

(1) Yes **(ask part a)**
(2) No **(go to question 29)**

a. How many car washes do you do per month?

__________________ number/month

DEMOGRAPHIC INFORMATION

Finally, we have several questions about you and your family. This data will be used only for analysis, so again, let me remind you that all of your responses are completely confidential.

29. Sex of respondent: **(INTERVIEWER: CIRCLE ANSWER; DO NOT ASK!)**

(1) Male
(2) Female

30. What is your marital status? **(INTERVIEWER: CIRCLE RESPONSE)**

(1) Married
(2) Widowed
(3) Divorced
(4) Separated
(5) Never married

31. Counting yourself, how many people live in your household?

__________ number

32. Please tell me the age and sex of each person living in your household.

Household Member	Sex (M or F)	Age (in years)
Respondent	__________	__________
Spouse	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________

33. Which of the following best describes the place where you now live? Is it: **(INTERVIEWER: READ CATEGORIES AND CIRCLE RESPONSE)**

(1) Within city boundaries
(2) In a built up area near city boundaries
(3) In the open country

34. What is the <u>number of years</u> of formal education you have completed?

__________ years

35. What is the <u>number of years</u> of formal education your spouse has completed? **(INTERVIEWER: ASK ONLY IF MARRIED; RECORD YEARS COMPLETED)**

__________ years

36. With which racial or ethnic group do you identify? **(INTERVIEWER: CIRCLE RESPONSE)**

(1) White
(2) Black
(3) Hispanic
(4) American Indian
(5) Chinese
(6) Vietnamese
(7) Other: (Specify) ______________

37. I am going to read several income categories. Then please tell me the income category which includes your family's 1985 income from all sources before deductions and taxes.

(INTERVIEWER: READ CATEGORIES THEN CIRCLE RESPONSE)

(1) Under $5,000
(2) $ 5,000 to $ 9,999
(3) $10,000 to $14,999
(4) $15,000 to $19,999
(5) $20,000 to $24,999
(6) $25,000 to $29,999
(7) $30,000 to $34,999
(8) $35,000 to $39,999
(9) $40,000 to $49,999
(10) $50,000 or more

38. Please describe the kind of work that you do.

(INTERVIEWER: PROBE TO GET ENOUGH INFORMATION TO DETERMINE <u>BOTH</u> OCCUPATION AND INDUSTRY)

____ Occupation

____ Industry

39. How long have you worked at this job? ______________ years

40. Do you work full-time (that is, 40 hours or more per week) or part-time at this job?

(1) Full-time
(2) Part-time

41. Please describe the kind of work that your spouse does.

(INTERVIEWER: ASK ONLY IF MARRIED; PROBE FOR OCCUPATION AND INDUSTRY)

____ Occupation

____ Industry

42. How long has he/she worked at this job?

______________ years

43. Does he/she work full-time (40 hours or more per week) or part-time at this job?

(1) Full-time
(2) Part-time

44. How long have you lived in this community? ____years ____months

(INTERVIEWER: RECORD RESPONSE; IF MORE THAN 5 YEARS, CONCLUDE SURVEY; IF LESS THAN 5 YEARS, ASK QUESTION 45)

45. Where did you live before coming to this community?

City ___________________________

County _________________________

State __________________________

Non-U.S. Residents only:

Country ________________________

This concludes our interview. Thank you very much for your cooperation.