Research Project Technical Completion Report

Project No. A-025-PR

COMPARATIVE ANALYSIS of RESIDENTIAL WATER USE in PUERTO RICO

by

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Water Resources Research Institute

Mayaguez, Puerto Rico

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ABSTRACT

This study was conducted with the objectives of developing residential water use models for the cities of Ponce and San Juan, Puerto Rico, and comparing these models with a previously developed model for the city of Mayaguez, Puerto Rico. In the event of non-significant differences between these models, to pool all the data and develop a single model to apply for the whole Island of Puerto Rico, as represented by these three main cities.

In order to fulfill these objectives, data from a random sample of dwellings in each city, on socioeconomic and demographic factors, together with water-use data, was subject, among others: to the computer-generation of transformed data required for graphical analyses and model building; to graphical analysis of the relationship between socioeconomic factors and water-use indices; to the computer-generation of model parameters; to regression plotbacks for the reliability of fitness in the computed models; and to model validations to determine the reliability of model performance.

These analyses showed that, for private urbanization dwellings, assessed property valuation and water use bear a relationship between them that may be approximated by an exponential function, with property value as the independent variable and water use as the reponse variable; a relationship which is similar to that obtained in the previous study conducted in the city of Mayaguez, Puerto Rico (13). As before, the property assessed value is used as a practical indirect indicator of the effect on water use of factors such as number and kind of home water-using fixtures, lawn and/or garden areas, automobile washing requirements; and such socioeconomic factors as habit, education and effective family

buying income.

After subjecting the developed models for Ponce and San Juan to comparative analyses (by testing the corresponding parameters for significant differences), no significant difference was detected between them, while, a highly significant difference was obtained from the comparison of Ponce and Mayaguez and San Juan and Mayaguez respectively. These results point towards the necessity of keeping separate models for the concerned cities and not pooling the data for a single model.

CHAPTER I- INTRODUCTION

The subject of residential water use has been under study in previous investigations conducted in the United States and abroad.

Hansen, Ross, Larson and Hudson (2 , 3) reported that a study conducted by the Illinois State Water Survey indicated residential water use in 1948 to be correlated with effective family buying income. Porges (5,7) stated that municipal water consumption (including residential water use) is influenced by such factors as climate (temperature, rainfall, atmospheric conditions), size of community, type of community, costs of water and related effects of metering, water quality and availability of water. He stated that as the percentage of metering increases, water consumption (in gallons per capita daily) decreases, and that there is a tendency for per capita water use to decrease as annual precipitation increases. His study showed that in regionally grouping statistics about water usage, variations in water consumption could be observed for several parts of the United States. A more recent study revealed domestic water usage to be correlated with property assessed valuation and certain demographic and socioeconomic factors (12) . It showed that in addition to the water used to supply the necessities of life, the amount of domestic water use varied with habit, social requirements, general installation of meters, number and kind of water using fixtures and appliances and automobile washing requirements. The study also showed that the possession of water-using equipment increases water use significantly, and that the possession of such equipment is strongly influenced by demographic and socioeconomic factors. The author finally indicates that because of these factors, the specific results obtained are only valid for the area or region considered in the study, and thus are not necessarily transferable to other regions.

Another study conducted at the John Hopkins University showed that in addition to the forementioned factors, one that has a high influence on residential water use is the lawn an garden sprinling demand (11). This study revealed water use to be considerably higher in housing areas with large lots devoted to lawns and gardens.

A study conducted recently in the city of Mayaguez, Puerto Rico, resulted in the development of mathematical models to correlate water use with property assessed valuation and number of bedrooms per dwelling unit in private and public type dwellings respectively. In order to see if the resulting models were applicable to other areas of Puerto Rico as well a comparative study for three main cities of Puerto Rico was also conducted. Succeeding chapters present the analyses performed and the results obtained from that comparative study.

CHAPTER II- COLLECTION OF SOCIOECONOMIC DATA

The required data on certain socioeconomic and demographic factors was obtained mainly from the sampling of residential areas in Ponce and San Juan, Puerto Rico . A suitable questionnaire was designed and interviews were conducted in the selected dwelling units of these areas.

2.1 General Procedure

The sampling procedure followed in the previous study conducted in the city of Mayaguez, Puerto Rico called for the subdivision of the area to be sampled into sampling tracts, city blocks and block segments. Based on the available information on the number of dwellings in each tract and city block, a sampling procedure was established which called for the random selection of city tracts, followed by a selection of city blocks and finally block segments which usually contained from 7 to 12 dwelling units. All dwelling units in each selected segment were canvassed. Dwelling units within tracts, blocks and segments were serially numbered and the selections were done by means of random numbers. Students which acted as interviewers were subject to a training program and supplied with all the required materials for the field work (8-10,13). Although the procedure followed for the selection of the required samples in the cities of Ponce and San Juan was basically the same, in order to some how simplify the process, the selection of segments within city blocks was done using a "random start" approach. (See Figure 2.1)

Figure 2.1
Interviewer at work

2.2 Private Urbanization Areas Sampled

The data obtained in the cities of San Juan, Ponce and Mayaguez was the result of canvassing the following private urbanization areas:

In San Juan, Puerto Rico:

Alturas de Torrimar
Bayamón Gardens
Flamingo Hills
Forest Hills
Forest View
Garden Hills
Royal Palms
Santa Juanita
Torremolinos
Victor Braegger
Villa Rica

In Ponce, Puerto Rico:

Buena Vista
Constancia
Extensión Alhambra
Jardines Fagot
Perla del Sur
Reparto Universitario
San Antonio
Valle Verde
Villa Grillasca
Vista Alegre

In Mayaguez, Puerto Rico:

Alemañy

Guanajibo

La Riviera

Las Mesas

Ensanche Martínez

Mayaguez Terrace

Ensanche Ramírez

Vista Verde

2.3 Questionnaire

A suitable questionnaire was used as a guide in conducting the required interviews with dwelling units tenants and as a means of collecting and recording socioeconomic and demographic information. This questionnaire calls for information to identify the study area, the dwelling unit being canvassed, time of residence for present tenants, and their address. It also covers some characteristics of the study area such as, dwelling class, dwelling units per structure, dwelling density, source of water, means of conveying water to the house, bathroom facilities seweage disposal, water-using kitchen facilities, clothes washing facilities, lawn and garden areas, number of automobiles owned or regularly used by the family, swimming pools, and evaporative air conditioning units. Another section of the questionnaire calls for data on the amount of water used during the study period and the assessed property value of the concerned dwelling unit. Figure 2.2 presents a sample questionnaire.

FIGURE 2.2

UNIVERSIDAD DE PUERTO RICO

MAYAGUEZ, PUERTO RICO

Entrevistador: P. Nazario

INSTITUTO DE INVESTIGACIONES DE RECURSOS DE AGUA

ANALISIS DEL CONSUMO RESIDENCIAL DE AGUA

SAMPLE

Fecha: 4-5-71

CUESTIONARIO A - 100 DATOS SOBRE CARACTERISTICAS RESIDENCIALES

IDENT. DE AREA

a- Municipio Ponce
b- Sector Censal P-40
o
c- D. de E. número -
d- Manzana núm. o combinación 4
e- Segmento núm. 2
f- Unidad de Vivienda (en el segmento) núm. 6

g- Tiempo que residen aquí 5 años 2 meses
h- Dirección: Urb. La Rambla Casa núm. -
-- Apto. núm.
-- Urbanización
Piso núm. --

1- CLASIFICACION DE VIVIENDA:

- Urbanización privada (X) 1
- Urbanización pública ( ) 2
- Condominio ( ) 3
- Casa apartamento ( ) 4
- Pueblo viejo ( ) 5

2- NUMERO DE UNIDADES EN LA ESTRUCTURA 1

3a.- Número de personas que viven en esta unidad mayores: 3 menores: 1 Desocupada ( )

3b.- Número de dormitorios en esta unidad

- Uno ( ) 1
- Dos ( ) 2
- Tres (X) 3
- Cuatro ( ) 4
- Más de cuatro ( ) 5 Indique ____

4- ORIGEN DEL AGUA (Acueductos y otros)

- Acueducto público (X) 1
- Pozo privado ( ) 2
- Cisterna ( ) 3
- Canal de riego ( ) 4
- Manantial u otro ( ) 5

Cuenta Núm. ------

5- SUMINISTRO DE AGUA

Sólo Por tuberías dentro de la estructura

- Caliente y Fría (X) 1
- Fría solamente ( ) 2

Sólo Por tuberías fuera de la estructura

- En la propiedad ( ) 3
- En la carretera ( ) 4
- Ambas ( ) 5

Sin agua corriente por tuberías ( ) 6

6- SERVICIO SANITARIO (Total) 1

6a.- Inodoro dentro de la estructura

- Para uso exclusivo (X) 1
- Para uso de varias unidades ( ) 2

Inodoro f...

6b.- Ducha con bañera

- Para uso exclusivo (X) 8
- Para uso de varias unidades ( ) 9

6c.- Ducha sin bañera

- Para uso exclusivo ( ) 10
- Para uso de varias unidades ( ) 11
- Sin ducha o bañera ( ) 12

6d.- Lavabo

- Para uso exclusivo (X) 13
- Para uso de varias unidades ( ) 14

6e.- Bidet Sí ( ) 15 No (X) 16

7- DISPOSICION DE AGUAS NEGRAS

- Alcantarillado público (X) 1
- Tanque séptico o sumidero ( ) 2
- Otro ( ) 3
- Ninguno ( ) 4

8- AGUA CORRIENTE EN LA COCINA:

- Fregadero (X) 1
- Triturador de desperdicio ( ) 2
- Lavaplatos ( ) 3
- Sin agua corriente Coc. ( ) 4

9. Servicio de lavado

a. máquina de lavar ropa

- Automática ( ) 1
- No automática y semi. (X) 2
- No tiene ( ) 3

b. Pileta ( )

10- GRAMA O JARDIN Sí (X) 1 No ( ) 2

11- AUTOMOVIL (Propiedad o regularmente usado por personas en esta unidad)

- Uno (X) 1
- Dos o más (Indique) ( ) 2
- Ninguno ( ) 3

12- Piscina Sí (X) 1 No ( ) 2

2.4 General Description of the "Private Urbanization Dwelling Concept" Employed in this Study

The non-commercial residential structures serving as dwelling places considered in this study (dwelling units) were defined to correspond with the Puerto Rico Bureau of the Property Assessment building classification code (6) . Residences defined as "private" dwellings, correspond to either use types A or B, construction class THREE, subclasses 3, 4, 5 or 6. These typically have foundations of continuous reinforced concrete wall, exterior walls of block or reinforced concrete, with columns, partition walls, floors, and roof of reinforced concrete block, tile, or other non-conbustible materials, usually allowing accommodations for one or two families. (See Figure 2.3)

2.5 Water-Use Data

Bi-monthly water-bill readings served as the basic water-use data for individual dwelling units. After proper identification of the dwelling account number, student assistants searched for corresponding water bill data from the records in the Puerto Rico Aqueduct and Sewer Authority Regional Offices. The data collected for the study conducted in Mayaguez and the present study for Ponce and San Juan covers from November 1965 to October 1971. The maximum bi-monthly reading and the accompanying average were identified and recorded. Based on the collected data two main water-use indices were determined: equivalent gallons per capita daily (gpcd), and equivalent gallons per day per dwelling unit (gpd)

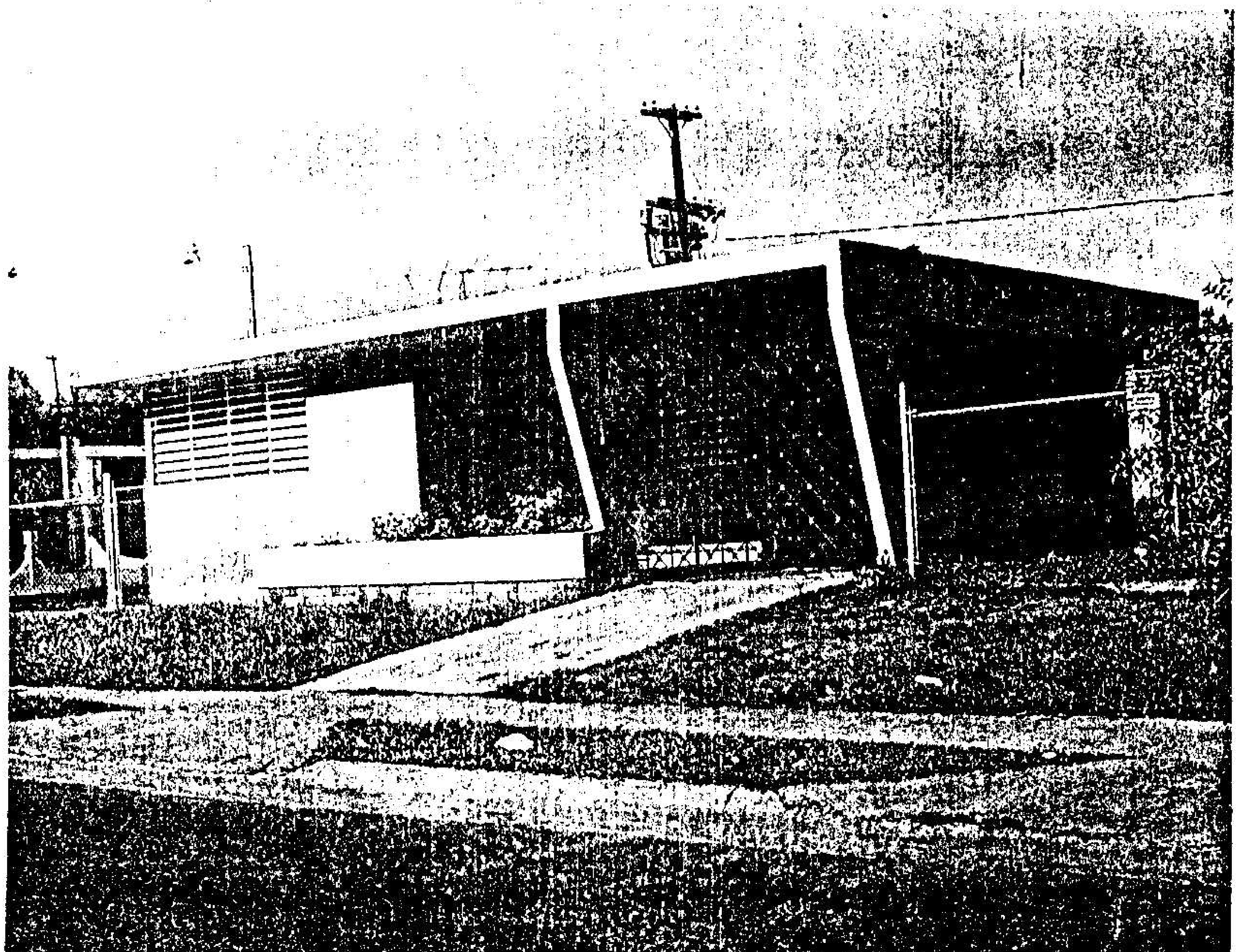


Figure 2.3
Typical Private Urbanization
Dwelling

2.6 Property Assessment Data

For the purposes of this study, the "assessed property value" of each dwelling unit is considered as a practical indirect indicator of some socioeconomic factors which are known to influence residential water use (3 , 12). The main portion of the data on property valuation used in this study came from the records of the Puerto Rico Bureau of the Property Assessment. Professional property assessors were contracted to evaluate those dwellings for which no valuation was registered in the Bureau. Whenever used in this report the term "property value" is understood to mean "property assessed value", as practiced in Puerto Rico since the last general reassessment of real estate property took place (1958-59), and includes the value for both the house and its lot (land).

2.7 Water Pressure and Water Quality Data

During the first stages of the previous study conducted in the city of Mayaguez, Puerto Rico, these two factors were studied for their possible inclusion in the model under development (13). An analysis-of-variance study revealed that there was no significant influence of water pressure on water use even for extremely wide variations in water pressure. (Confer Reference 13 for more datails) The degree of hardness (water quality characteristic originally under consideration) was also discarded as an influencing factor because of its relatively controlled condition in the study areas covered. (1)

CHAPTER III- COMPARISON OF SOME PHYSICAL, SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF THE SELECTED DWELLING UNIT SAMPLES

Since residential water use is known to be influence by several socioeconomic and demographic factors, this study considered various characteristics of the study areas and its selected samples of dwelling units (12).

3.1 Characteristics Studied

Socioeconomic and Demographic Characteristics considered:

- Daily water use per dwelling unit
- Daily water use per person
- Number of Adults in each dwelling unit
- Number of children in each dwelling
- Number of years residing in same place
- Number of automobiles owned
- Assessed property value

Physical Characteristics considered:

- Building class of dwelling unit
- Dwelling units per structure
- Number of bedrooms per unit
- Sources of water
- Means of conveying water to dweling unit
- Bathroom facilities
- Seweage disposal facilities
- Kitchen water-using facilities
- Laundering facilities

- Lawn and garden areas
- Swimming pools
- Evaporative air conditioner

3.2 Comparative Summary of Some Characteristics of the Samples Collected in the Cities of San Juan, Ponce and Mayaguez

Although this study considered all the characteristics listed in section 3.1, only some of these were judged of greatest interest for our present analysis, and thus were used to compare the samples obtained from the cities of San Juan, Ponce and Mayaguez.

These characteristics were:

- The assessed property value
- The number of bedrooms per dwelling unit
- The number of gallons per day per dwelling unit of water used in the equivalent month of average water-use
- The number of gallons per day per dwelling unit of water used, in the equivalent month of maximum water-use
- The number of gallons of water used in one day per person, in the equivalent month of average water-use
- The number of gallons of water used in one day per person, in the equivalent month of maximum water-use
- The number of persons per dwelling unit

Table 3.1 presents a comparative summary of these physical, socioeconomic and demographic characteristics.

3.3 Some Comments on Observed Differences in Characteristics

TABLE 3.1

Comparative Summary of Some Physical, Socioeconomic and Demographic Characteristics of the Model-Development Samples for the Cities of San Juan, Ponce and Mayaguez, Puerto Rico

Private Urbanization Dwellings

Dwelling Characteristic	San Juan			Ponce			Mayaguez		
	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.
1. Assessed Property value ($)	7,160.00	15,817.73	39,190.00	5,060.00	10,941.00	23,320.00	5,590.00	13,665.00	23,270.0C
2. Number of Bedrooms per Dwelling	3	3.6	4	2	3.5	5	2	3.3	5
3. Gallons per Day per Dwelling Unit of Water Used in AVEMO	112	317	1,239	77	297	1,438	90	237	549
4. Gallons per Day per Dwelling Unit of Water Used in MAXMO	122	414	1,839	113	372	2,240	96	296	863
5. Gallons per Capita Daily of Water Used in AVEMO	28	78	309	26	67	359	29	63	135
6. Gallons per Capita Daily of Water Used in MAXMO	30	101	566	30	84	560	32	79	205
7. Population Density (persons per dweling unit)	2	4.2	6	1	4.6	9	2	5.1	9

It could be noted that the lowest average property value was registered in Ponce and the highest in San Juan corresponding to $10,941.00 and $15,817.73 respectively. The highest individual value registered was $39,190.00 and the lowest $5,060.00. These correspond to San Juan and Mayaguez, Puerto Rico respectively.

No significant difference is observed in the average number of bedrooms per dwelling unit for the three cities, centered in about 3.5. The minimum registered was 2 and the maximum 5 rooms per dwelling unit.

Population density (persons per dwelling unit) does not seem to differ significantly for the three cities with an average of about 4.6 persons per dwelling unit. The lowest figure registered was 1 and the highest 9 persons per unit in the three cities. Although no definite difference could be ascertain just by observing the figures on water use depicted in Table 3.1, the average figures for Mayaguez appear somehow lower than the corresponding figures for Ponce and San Juan. The analytical comparison conducted in chapter VIII clarifies this point.

CHAPTER IV- GENERATION OF EQUIVALENT WATER-USE INDICES

In order for the data to be more properly analyzed, the raw data was converted in equivalent water use indices.

4.1 Data Codification

All the data from the filled in questionnaries was transfered into coding forms following a set of pre-defined codes for all main data classes and sub-classes. The completed coded forms were sent to the CAAM School of Engineering Computing Center for key-punching into cards.

Figure 4.1 shows a sample data card depicting its contents and format. These cards were prepared (one per dwelling unit) and used as input to the computer programs, that were previously written to do the required analysis, and the plotting of corresponding trend charts. (See Figures 4.2 and 4.3)

4.2 Equivalent Gallons per Day per Dwelling Unit (gpd)

Bi-monthly water-bill readings alone are not suitable for the intended analyses and corresponding model development process. In order to transform raw data to a more adequate form for dwelling units water use, the index known as "gallons per day per dwelling unit" was generated. Taking as basis the water-bill reading in cubic meters this index was determined as follows:

$$gpd = 264.2\ W_r\ /\ 60.6 \qquad (4.1)$$

where gpd stands for gallons per day per dwelling unit, 264.2 is the conversion factor from cubic meters to gallons, W_r is the water bill reading, and 60.6 is the average time period, in days,

Figure 4.1

Composition of Master Data Card

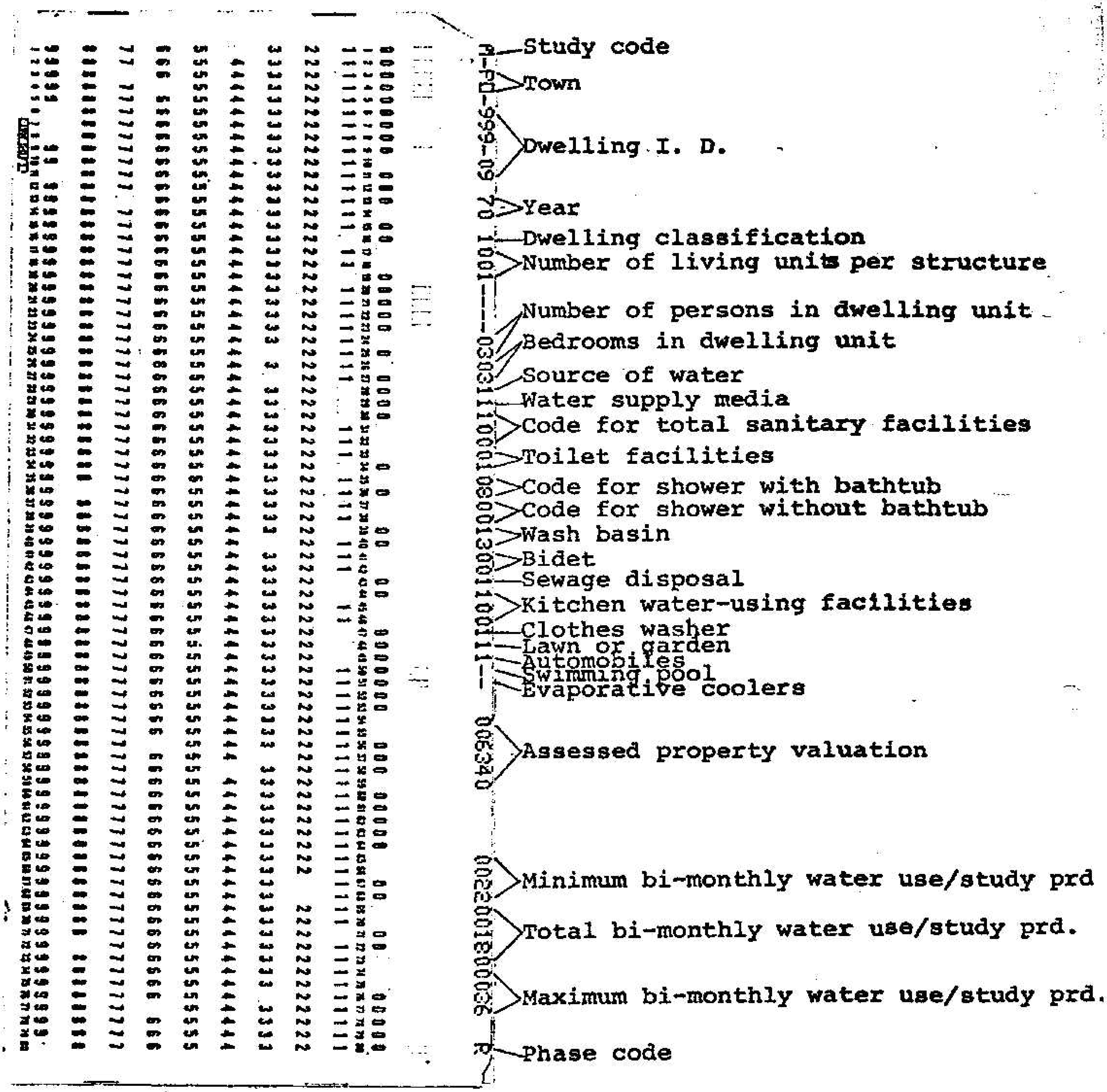


Figure 4.2
Preparing Master Data Cards

Figure 4. 3
Computer Analysis of Data

between regular meter readings.

4.3 Equivalent Gallons per Capita Daily (gpcd)

In addition to the water-use index defined in the preceeding section, a second index is also required for the intended analyses. This is known as "gallons per capita daily". Based on the estimated number of gallons per day per dwelling unit, this index is obtained as follows:

$$gpcd = gpd / TP \qquad (4.2)$$

where gpcd means gallons per capita daily, and TP is the total number of persons in a single dwelling unit.

4.4 Relevance of Water-Use Indices in the Design of Water Distribution Systems

The two previously defined water use indices are important in the design of water supply and distribution systems, because in such cases, one major consideration is that the distribution system should be capable of meeting the "maximum daily" (also the "peak hourly") demand rates. Similarly, the supply system from a reservoir or river should be designed so that it is capable of supplying water at the "maximum daily demand" rate and the pumping stations and transmission mains between reservoirs in the distribution system must be designed for flows in excess of the "maximum daily" demand.

The indices of Equations 4.1 and 4.2 will referred to in this study as "gpd in AVEMO or MAXMO" for gallons per day per dwelling unit computed from the average or maximum water bill readings, and "gpcd in AVEMO or MAXMO" for gallons per capita daily computed for similar bill readings. This two "generated" water use indices form the basic data for the analyses and appear as such in the remainder of this report and the computer printouts included herein.

CHAPTER V- GRAPHICAL ANALYSIS OF GENERATED WATER-USE INDEX DATA

In an effort to disclose a possible functional relationship between water use and property value, the previously generated water-use index data was subject to graphical analyses.

5.1 Water-Use Index Trend Data as Basis for the Appraisal of Model Form

The data on assessed property valuation and the water-use indices of Equations 4.1 and 4.2 were used to plot scattergrams of water use-vs-property value. Figures 5.1 to 5.8 present the plotted scattergrams for the cities of San Juan and Ponce in a semi-logarithmic framework. It could be seen, from the observation of these graphs, that water use in gallons per day per dwelling unit and gallons per capita daily, has a tendency to increase in a general linear trend when moving from lower property values to higher ones. This is true for the equivalent months of average water use (AVEMO) and the equivalent month of maximum water use (MAXMO).

5.2 Model Form as Inferred from the Observation of Scattergrams of Water Use -vs- Assessed Property Value

Because of the semilogarithmic framework, the linear trend observed in the scattergrams of the preceding section leads to the conclusion that the functions representative of the population under study, are members of a family of exponential functions. This in turn, leads to the hypothesis that the general form of the relationship is

$$W = \alpha e^{kV} \qquad (5.1)$$

Water Use
vs
Property Value
(in AVEMO)

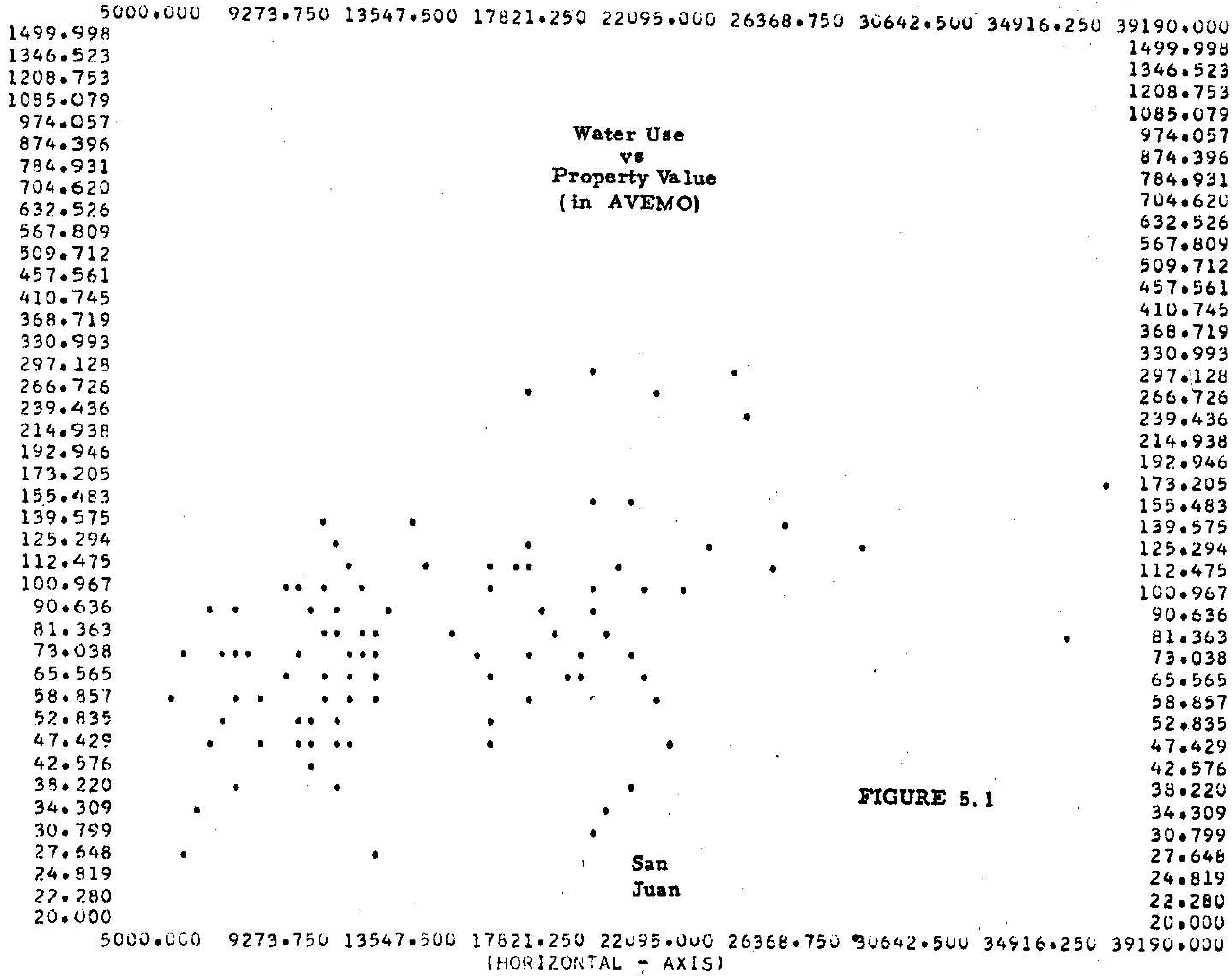


FIGURE 5.1

HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER CAPITA DAILY

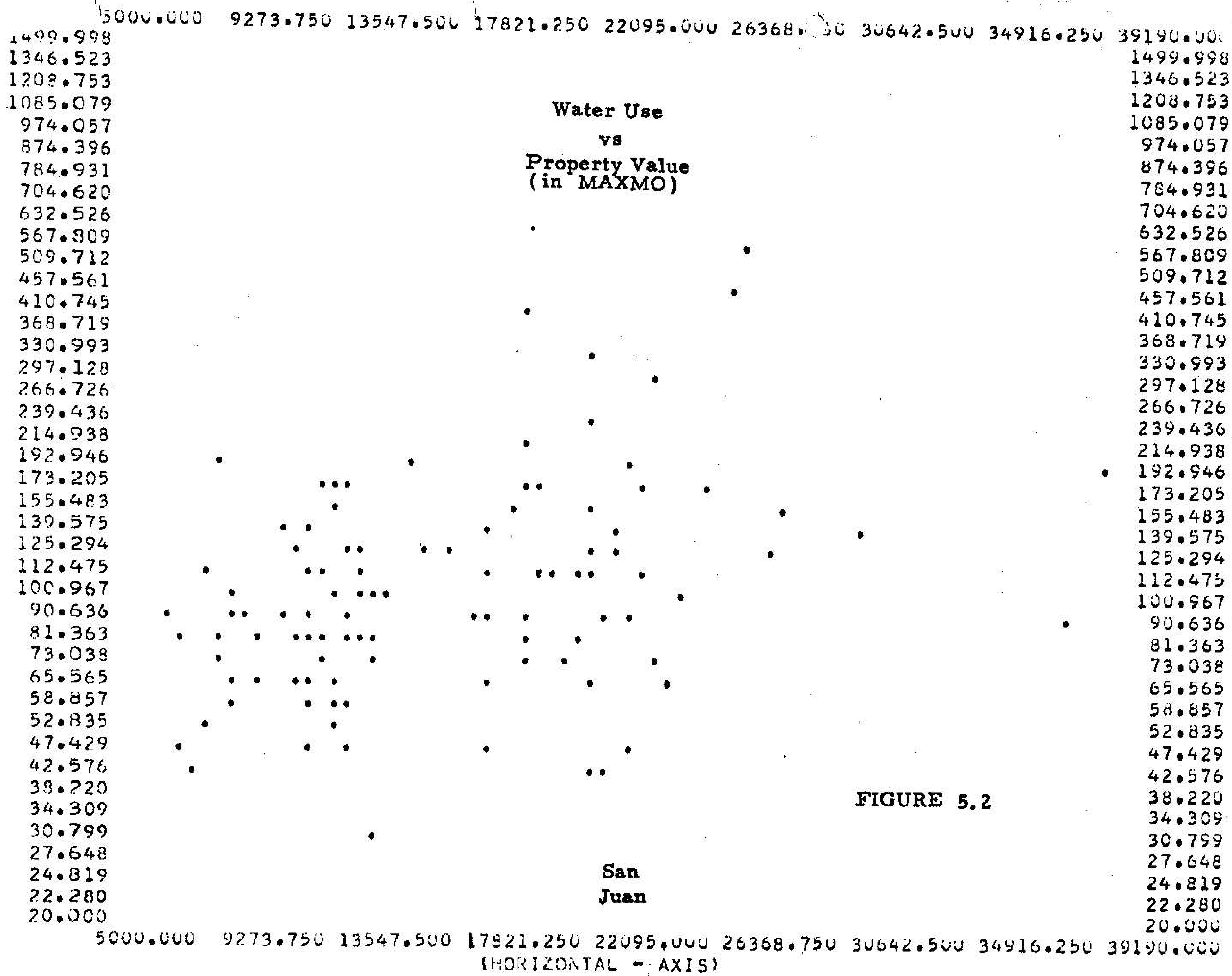
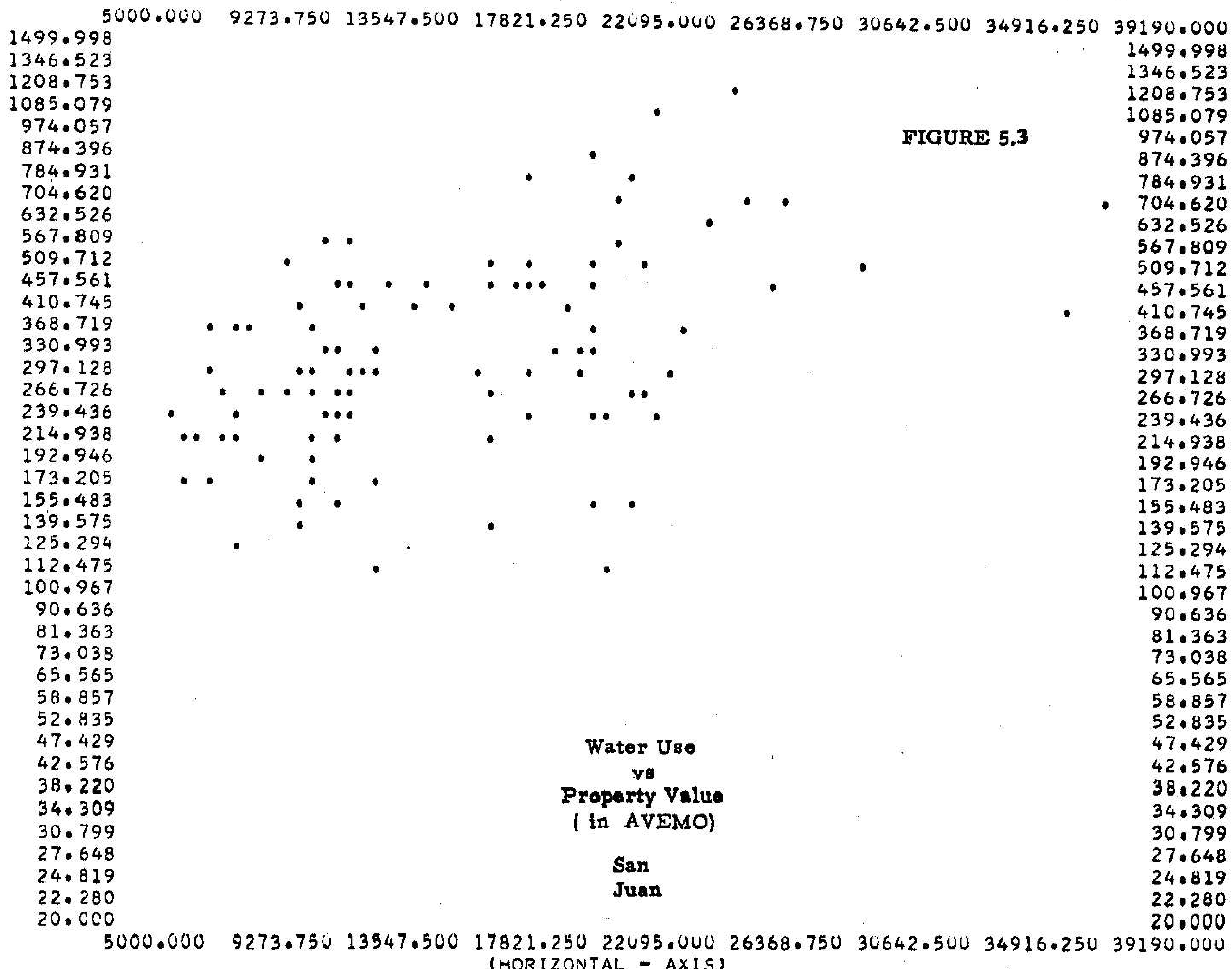


FIGURE 5.2

HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER CAPITA DAILY



HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER DAY PER DWELLING UNIT

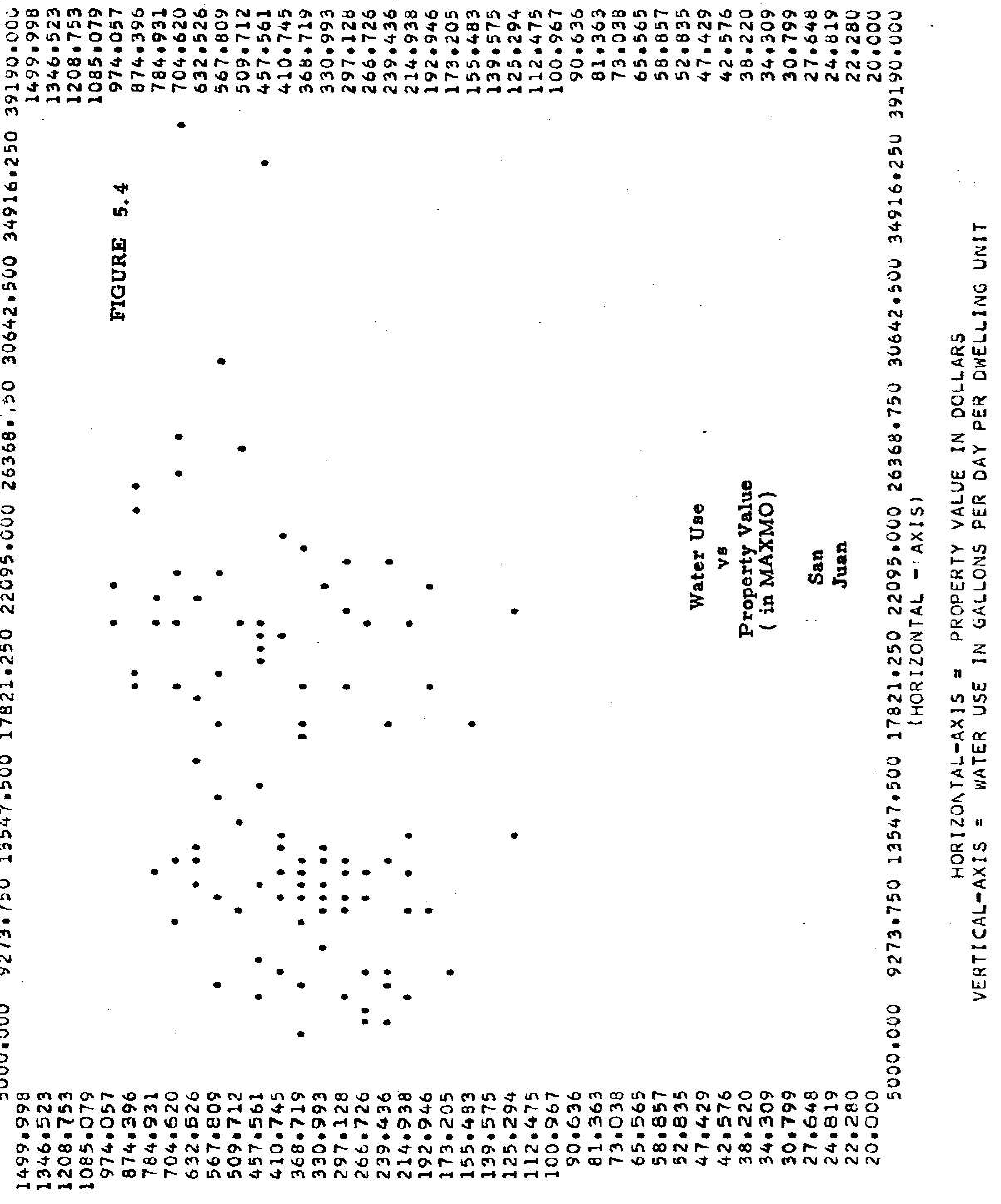
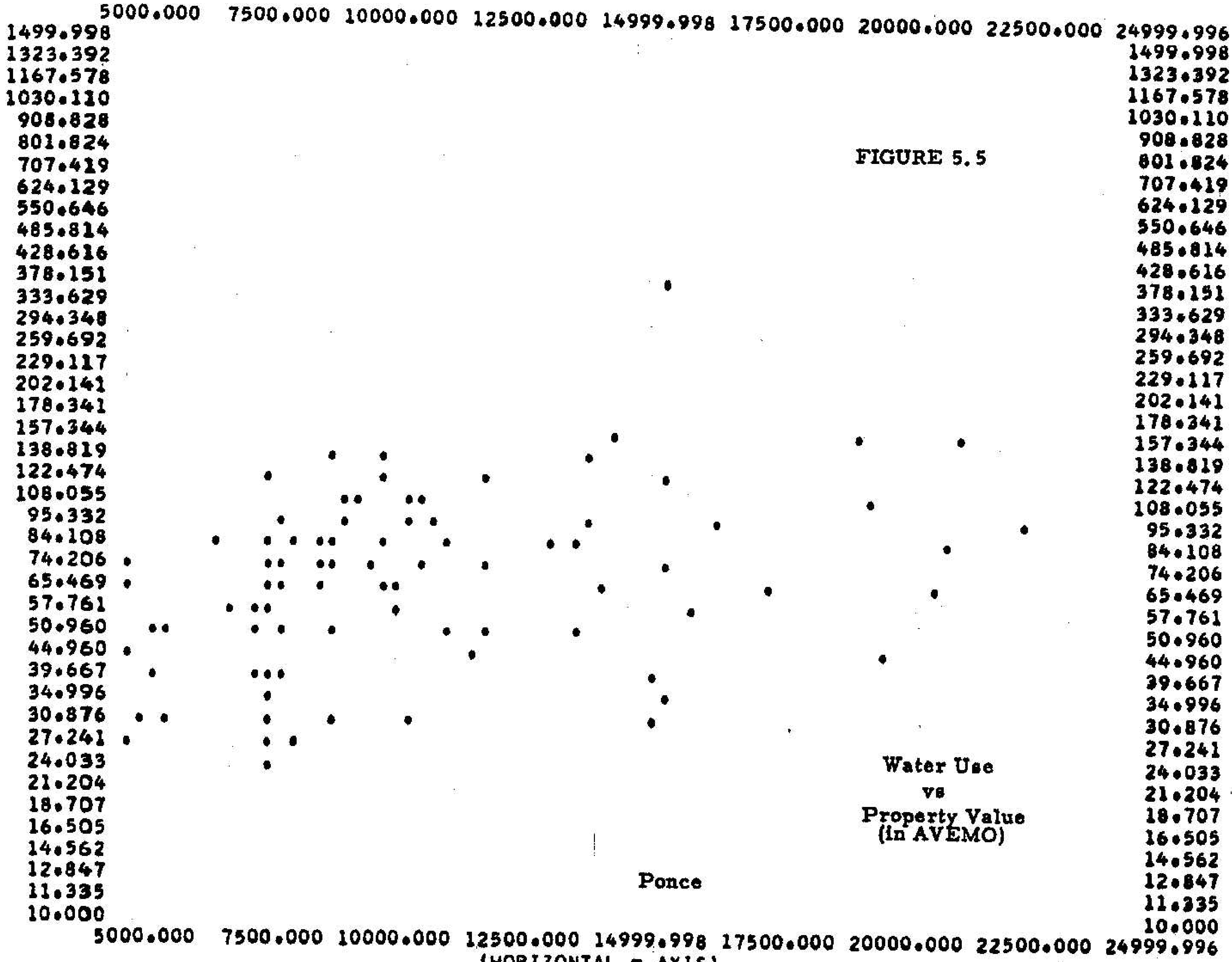
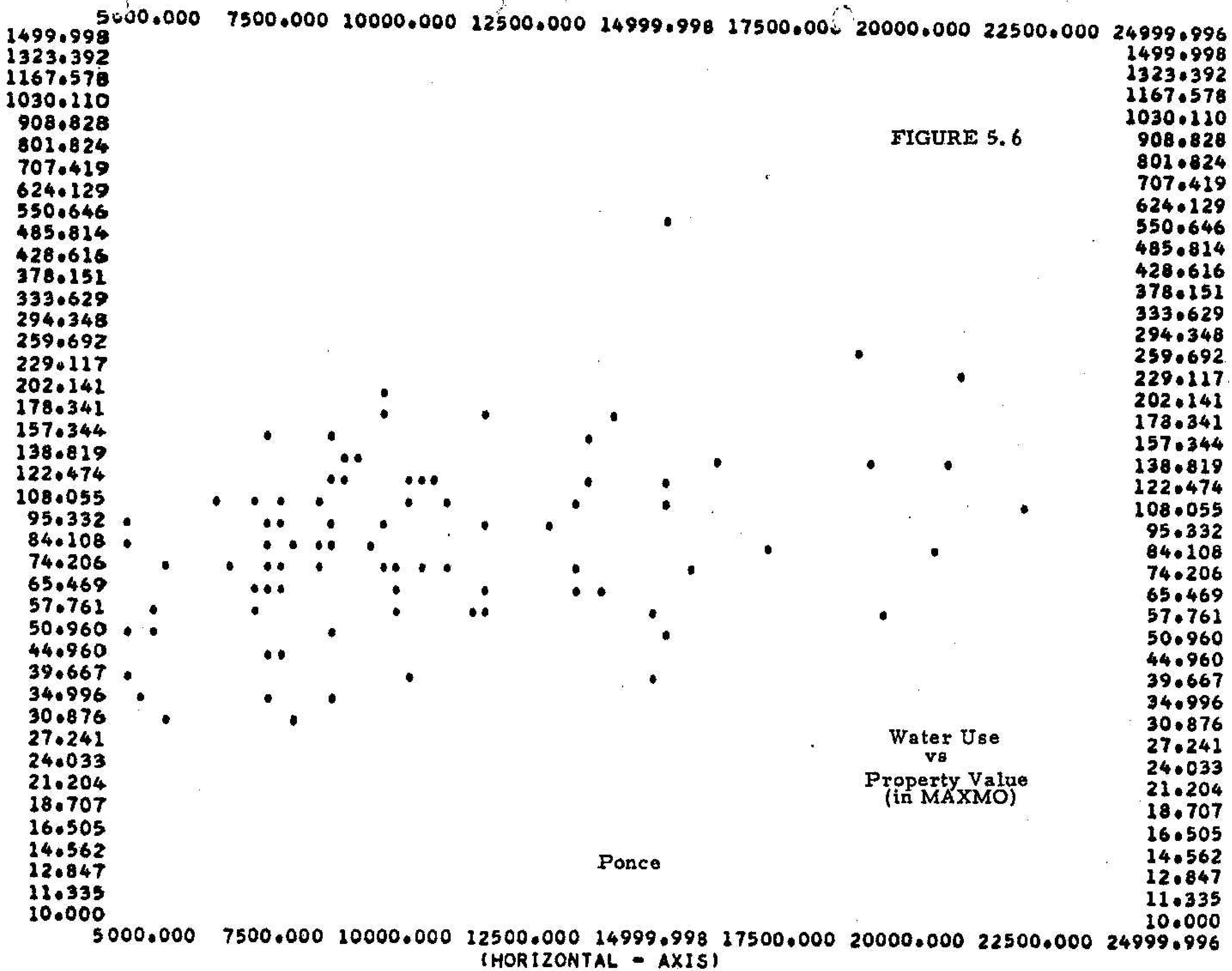


FIGURE 5.4
Water Use
vs
Property Value
(in MAXMO)
San
Juan
5000.000 9273.750 13547.500 17821.250 22095.000 26368.750 30642.500 34916.250 39190.000
1499.998
1346.523
1208.753
1085.079
974.057
874.396
784.931
704.620
632.526
567.809
509.712
457.561
410.745
368.719
330.993
297.128
266.726
239.436
214.938
192.946
173.205
155.483
139.575
125.294
112.475
100.967
90.636
81.363
73.038
65.565
58.857
52.835
47.429
42.576
38.220
34.309
30.799
27.648
24.819
22.280
20.000
(HORIZONTAL - AXIS)
HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER DAY PER DWELLING UNIT

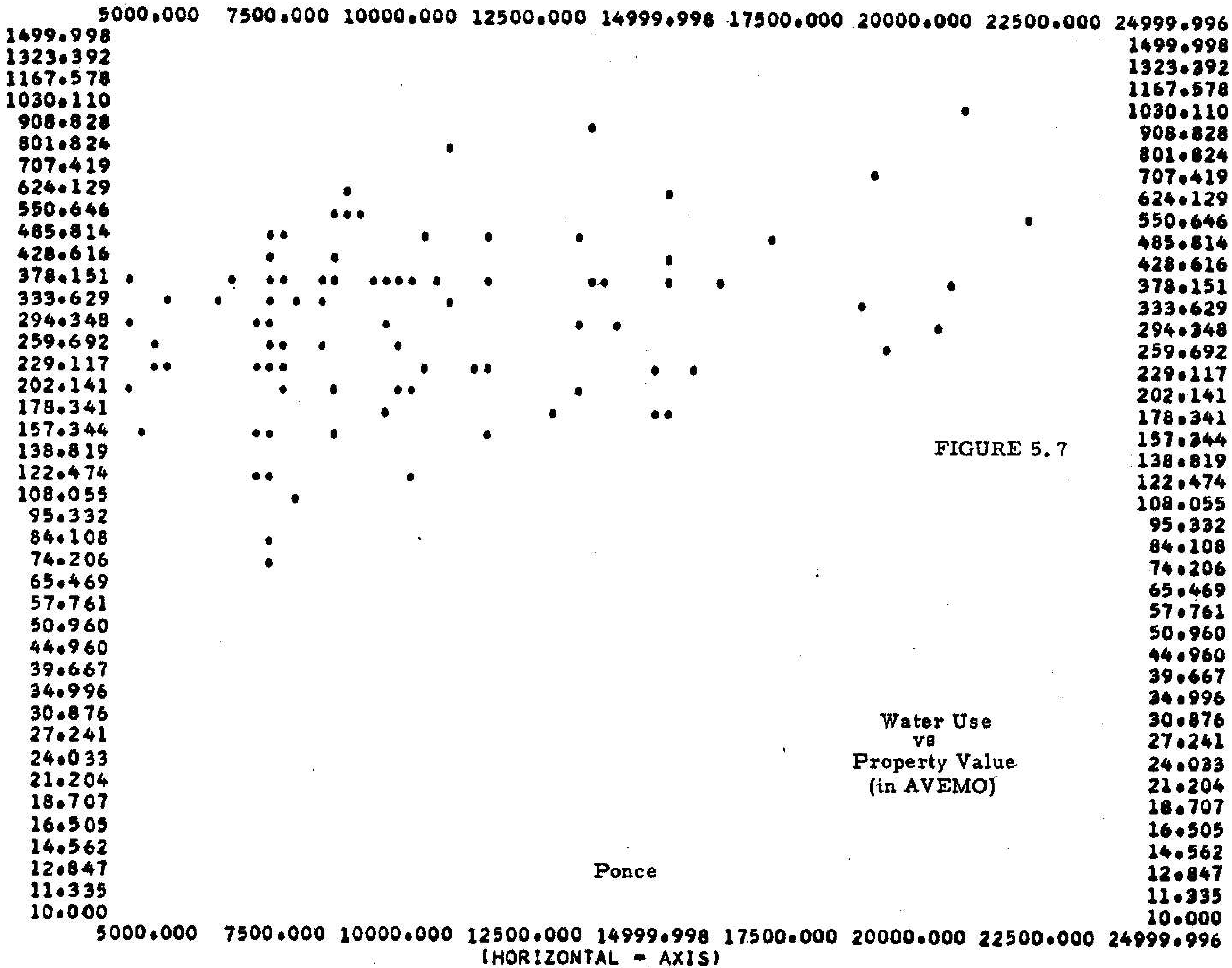
FIGURE 5.5



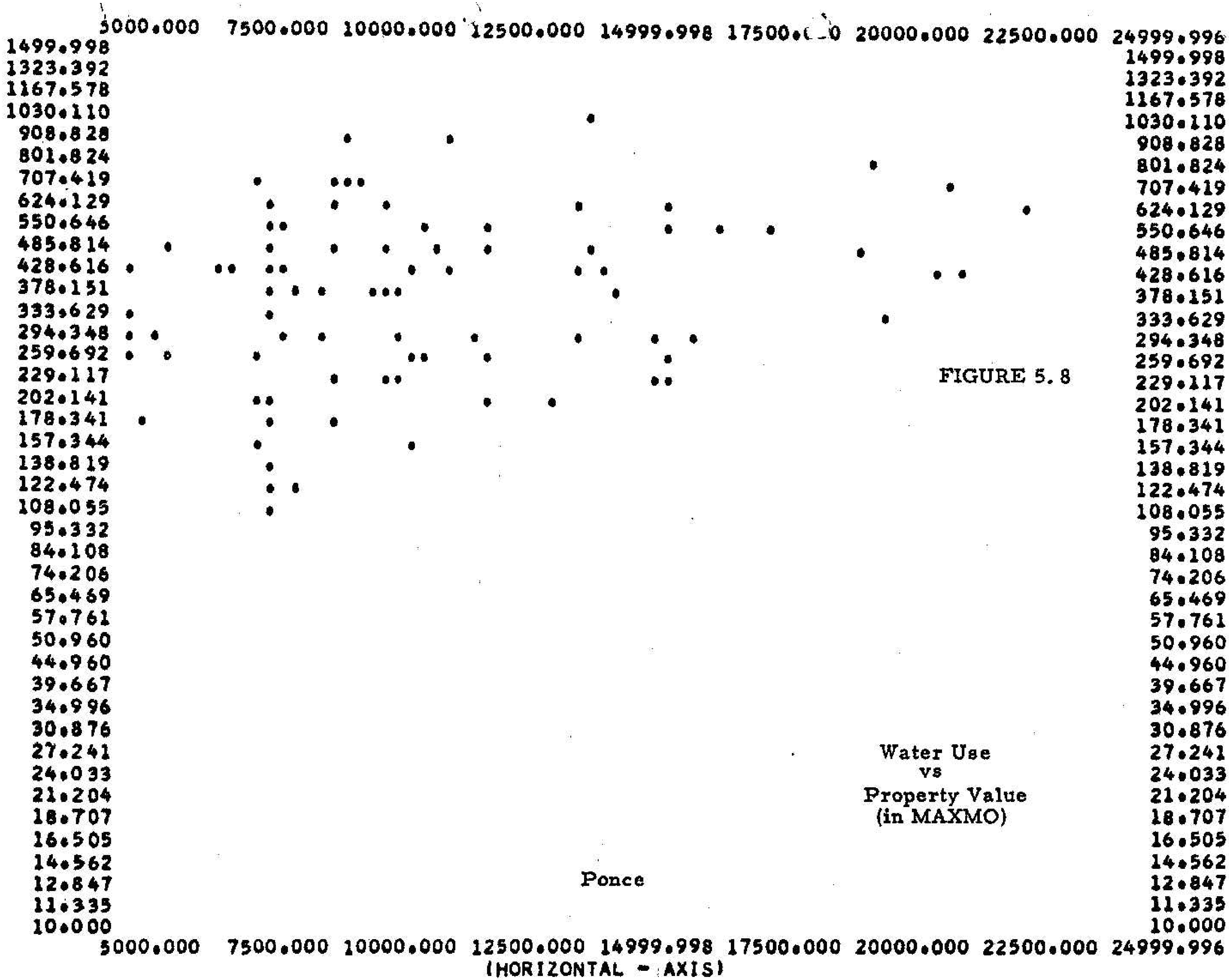
HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER CAPITA DAILY



HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER CAPITA DAILY



HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER DAY PER DWELLING UNIT



HORIZONTAL-AXIS = PROPERTY VALUE IN DOLLARS
VERTICAL-AXIS = WATER USE IN GALLONS PER DAY PER DWELLING UNIT

where W stands for water use, α and e^k are two model parameters, e is the base of the natural logarithms system 2.71828..., k is a model parameter constant, and V is the corresponding property value.

CHAPTER VI- MODEL GENERATION

6.1 Model Generation Analyses

In order to determine the best estimates of model parameters α and $_ek$, curve fitting techniques were applied to the sample data. To carry out the required computations, a computer program was prepared. The input to this program consists of master data cards containing, in code form, the collected data on dwelling characteristics and water use for each dwelling unit in the sample. This program produces a print out of: dwelling characteristics in tabular form, showing property values and water use in gallons per day per dwelling unit and gallons per capita daily for equivalent months of average and maximum water usage; a table of regression computational elements, with estimates for model parameter values; the resulting model in exponential and reduced forms; a regression plot back table; an analysis of variance table (ANOVA); variance estimates and confidence limits for model parameters; and the computed test-of-hypothesis values for t and F distributions.

6.1.1 Analysis of the San Juan Sample of Dwellings

For the determination of the required model parameters , Equation 5.1 was changed to its reduced form:

$$\ln W = \ln \alpha + kV \qquad (6.1)$$

where ln stands for natural or Maperian logarithm. Equation 6.1 was further modified, to simplify its presentation, by defining W_L and α_L as the natural logs of W and α respectively.

These changes made α_L and the new model parameters for analysis purposes. They appear in the computer analyses print out as LNA and LNB respectively.

Exhibit 6.1 presents the print out of some of the analyses carry on for the San Juan sample of dwellings.

6.1.2 Analysis of the Ponce Sample of Dwellings

The analyses conducted on the Ponce sample of dwellings were similar to those depicted for the San Juan sample.

Exhibit 6.2 is a print out of some of these analyses for the city of Ponce, Puerto Rico.

6.1.3 Analysis of the Mayaguez Sample of Dwellings

The analyses conducted in the Mayaguez area were similar to those presented here for San Juan and Ponce. The corresponding print out of results is not presented in this report since it was already included in the previous study report which form the basis for the present study. However, the data and results of the Mayaguez study required for this one, are included in the analyses and presented in the tabular comparisons whenever required by such analyses. For more datails on the Mayaguez area study, the reader should confer the 107-pages report for that area, whose tittle is listed in Appendix I of the present publication under reference 13 .

EXHIBIT 6.1
Some Results from the Analysis of the San Juan Private Urbanization Areas Data

UNIVERSITY OF PUERTO RICO
WATER RESOURCES RESEARCH INSTITUTE
MAYAGUEZ, PUERTO RICO

OUTPUT OF EXPONENTIAL REGRESSION-MODEL ANALYSIS PROGRAM

EXPONENTIAL REGRESSION-MODEL ANALYSIS FOR SOME SELECTED DWELLING CHARACTERISTICS WITH, ANALYSIS OF VARIANCE, REGRESSION PLOTBACK, VARIANCE ESTIMATES FOR MODEL PARAMETERS CONFIDENCE INTERVALS, AND TESTS OF HYPOTHESES. PROFESSOR A. GUILBE, INDUSTRIAL ENGINEERING DEPARTMENT/WATER RESOURCES RESEARCH INSTITUTE.

RESIDENTIAL WATER-USE PROJECT
MAIN SAN JUAN URBANIZATION DWELLINGS
SOME SELECTED DWELLING CHARACTERISTICS

INDIVIDUAL DWELLING I.D.	PROPERTY VALUE IN DOLLARS	PER DWELLING DAILY USE IN GALLONS FOR			PER CAPITA DAILY USE IN GALLONS FOR		
		MINMO	AVEMO	MAXMO	MINMO	AVEMO	MAXMO
-701 -1	22680.	645.	744.	932.	129.	148.	186.
-701 -2	20210.	392.	399.	453.	65.	66.	75.
-701 -3	18800.	252.	295.	366.	63.	73.	91.
-701 -4	19960.	209.	342.	462.	52.	85.	115.
-701 -5	18830.	209.	239.	296.	52.	59.	74.
-701 -6	23030.	470.	527.	592.	94.	105.	118.
-701 -7	23400.	87.	241.	305.	21.	60.	76.
-701 -8	22680.	226.	281.	348.	56.	70.	87.
-701 -9	17740.	435.	494.	558.	87.	98.	111.
-701-10	17210.	261.	295.	357.	65.	73.	89.
-702 -1	8180.	113.	210.	584.	37.	70.	194.
-702 -2	10810.	148.	161.	200.	49.	53.	66.
-702 -3	10710.	235.	309.	340.	58.	77.	85.
-702 -4	10710.	279.	295.	313.	69.	73.	78.
-702 -5	8334.	191.	212.	235.	63.	70.	78.
-702 -6	11380.	87.	217.	427.	17.	43.	85.
-702 -7	10310.	322.	517.	714.	64.	103.	142.
-702 -8	10930.	357.	422.	505.	89.	105.	126.
-702 -9	10830.	95.	138.	191.	31.	46.	63.
-703 -1	13300.	209.	286.	340.	52.	71.	85.
-703 -2	13460.	113.	171.	217.	37.	57.	72.
-703 -3	12610.	348.	312.	252.	69.	62.	50.
-703 -4	14930.	331.	418.	558.	110.	139.	186.
-703 -5	13750.	340.	338.	392.	68.	67.	78.
-703 -6	13515.	261.	331.	409.	65.	82.	102.
-703 -7	12260.	287.	470.	784.	57.	94.	156.
-703 -8	12740.	531.	558.	662.	106.	111.	132.
-703 -9	13110.	235.	295.	340.	78.	98.	113.
-703-10	13390.	78.	112.	122.	19.	28.	30.
-703-11	13390.	113.	284.	409.	28.	71.	102.

Exhibit 6.1
(Cont... 2)

-704 -1	11300.	244.	310.	374.	40.	51.	62.
-704 -2	10240.	209.	271.	357.	52.	67.	89.
-704 -3	14090.	331.	438.	505.	66.	87.	101.
-704 -4	15220.	392.	434.	479.	98.	108.	119.
-704 -5	11340.	331.	376.	575.	82.	94.	143.
-704 -6	16160.	270.	427.	627.	54.	85.	125.
-704 -7	11820.	313.	319.	331.	104.	106.	110.
-705 -1	9320.	104.	190.	340.	26.	47.	85.
-705 -2	9290.	226.	281.	331.	45.	56.	66.
-705 -3	11030.	130.	164.	209.	43.	54.	69.
-705 -4	11090.	200.	267.	305.	33.	44.	50.
-706 -1	27780.	636.	712.	741.	127.	142.	148.
-706 -2	21100.	549.	847.	967.	183.	282.	322.
-706 -3	25120.	435.	604.	871.	87.	120.	174.
-706 -4	18780.	575.	819.	1194.	191.	273.	398.
-706 -5	26660.	217.	710.	1700.	72.	236.	566.
-706 -6	23470.	906.	1100.	1246.	226.	275.	311.
-706 -7	27480.	383.	450.	505.	95.	112.	126.
-706 -8	22820.	148.	270.	714.	37.	67.	178.
-706 -9	18780.	235.	447.	837.	58.	111.	209.
-706-10	25950.	793.	1239.	1839.	198.	309.	459.
-706-11	30620.	392.	505.	558.	98.	126.	139.
-706-12	37770.	313.	415.	479.	62.	83.	95.
-706-13	39190.	549.	683.	741.	137.	170.	185.
-707 -1	12310.	200.	242.	296.	40.	48.	59.
-707 -2	11370.	156.	167.	270.	39.	41.	67.
-707 -3	11370.	226.	284.	340.	75.	94.	113.
-707 -4	12310.	265.	324.	392.	66.	81.	98.
-707 -5	11830.	52.	241.	322.	13.	60.	80.
-707 -6	11430.	139.	203.	383.	34.	50.	95.
-707 -7	12200.	174.	209.	270.	43.	52.	67.
-708 -1	7810.	165.	180.	209.	41.	45.	52.
-708 -2	9040.	217.	364.	444.	43.	72.	88.
-708 -3	8100.	226.	277.	383.	45.	55.	76.
-708 -4	7920.	279.	358.	462.	69.	89.	115.
-708 -5	8380.	209.	239.	270.	52.	59.	67.
-708 -6	7550.	261.	284.	313.	43.	47.	52.
-708 -7	6610.	130.	172.	270.	21.	28.	45.
-708 -8	7160.	191.	209.	261.	31.	34.	43.
-708 -9	6500.	156.	231.	383.	39.	57.	95.
-708-10	6610.	139.	215.	252.	46.	71.	84.
-709 -1	12990.	418.	409.	627.	83.	81.	125.
-709 -2	12990.	217.	313.	392.	54.	78.	98.
-709 -3	12260.	200.	263.	357.	100.	131.	178.
-709 -4	12260.	130.	152.	217.	32.	38.	54.
-709 -5	12730.	305.	456.	723.	76.	114.	180.
-709 -6	11704.	462.	572.	662.	115.	143.	165.
-709 -7	17550.	104.	136.	148.	34.	45.	49.
-709 -8	19270.	409.	457.	540.	81.	91.	108.
-709 -9	19145.	191.	251.	313.	47.	62.	78.
-709-10	21510.	165.	242.	287.	55.	80.	95.
-709-11	17450.	366.	457.	558.	91.	114.	139.
-709-12	12840.	235.	293.	366.	58.	73.	91.
-709-13	12700.	165.	260.	322.	41.	65.	80.
-709-14	17540.	174.	217.	252.	43.	54.	63.
-709-15	19170.	366.	499.	723.	91.	124.	180.

Exhibit 6.I
(Cont... 3)

-709-16	17450.	217.	276.	374.	54.	69.	93.
-709-17	12580.	156.	242.	305.	31.	48.	61.
-709-18	19300.	270.	451.	880.	54.	90.	176.
-709-19	11580.	244.	315.	470.	61.	78.	117.
-709-20	11910.	244.	322.	383.	48.	64.	76.
-710 -1	24460.	348.	386.	418.	87.	96.	104.
-710 -2	21060.	130.	154.	209.	26.	30.	41.
-710 -3	21020.	244.	356.	453.	61.	89.	113.
-710 -4	21060.	217.	348.	505.	54.	87.	126.
-710 -5	20980.	401.	497.	758.	80.	99.	151.
-710 -6	21050.	366.	463.	741.	122.	154.	247.
-710 -7	21110.	209.	244.	279.	52.	61.	69.
-710 -8	18290.	270.	457.	619.	67.	114.	154.
-710 -9	20930.	122.	300.	453.	30.	75.	113.
-710-10	23750.	217.	283.	383.	36.	47.	63.
-710-11	20950.	296.	345.	409.	59.	69.	81.
-710-12	21850.	108.	108.	130.	36.	36.	43.
-710-13	22120.	514.	552.	619.	102.	110.	123.
-710-14	22200.	549.	713.	828.	91.	118.	138.
-710-15	22480.	43.	161.	191.	10.	40.	47.
-711 -1	8410.	191.	216.	270.	63.	72.	90.
-711 -2	8400.	52.	120.	174.	17.	40.	58.
-711 -3	8400.	305.	350.	418.	76.	87.	104.
-711 -4	8400.	209.	225.	244.	52.	56.	61.

KSELEC= 5

REGRESSION COMPUTATIONAL ELEMENTS

N= 110.

V=	1739.95044231	SLNW=	478.55230796		
VEV=	15.81772997	AVELNW=	4.35047532		
V2=	32118.36724090	SLNW2=	2106.18213558	SVTLNW=	7720.30567550
SMV=	27522.06254577	SSMLNW=	2081.92969417	SSMVLW=	7569.61036491
SSV=	4596.30567550	CSSLNW=	24.25244526	CSSVLW=	150.69534337

LNA= 3.83187151 LNB= 0.03278619

THE CORRESPONDING REGRESSION MODEL IS

LNW= 3.83187151 + 0.03278619* V IN REDUCED FORM

W = 46.14880380 * 1.03332972 ** V IN EXPONENTIAL FORM

REGRESSION PLOTBACK

V	LNW	LNWH	DLWH	DLWH2
22.680	5.00268555	4.57546235	0.42722326	0.18251967

Exhibit 6.1
(Cont... 4)

20.210	4.19881059	4.49448014	-0.29566961	0.08742049
18.800	4.30071068	4.44825173	-0.14754107	0.02176836
19.960	4.45133591	4.48628331	-0.03494740	0.00122132
18.830	4.09344960	4.44923497	-0.35578543	0.12658324
23.030	4.65876389	4.58693696	0.07182694	0.00515910
23.400	4.09949208	4.59906770	-0.49957567	0.24957582
22.680	4.25536252	4.57546235	-0.32009989	0.10246391
17.740	4.59330655	4.41349793	0.17980864	0.03233113
17.210	4.30071068	4.39612198	-0.09541131	0.00910331
8.180	4.25191975	4.10006238	0.15185740	0.02306066
10.810	3.98471642	4.18628979	-0.20157292	0.04063163
10.710	4.34879685	4.18301106	0.16578581	0.02748493
10.710	4.30071068	4.18301106	0.11769963	0.01385320
8.334	4.25879288	4.10511113	0.15368178	0.02361808
11.380	3.77499628	4.20497800	-0.42998129	0.18488386
10.310	4.63929082	4.16989709	0.46939379	0.22033047
10.930	4.66082764	4.19022465	0.47060304	0.22146719
10.830	3.82906294	4.18694592	-0.35788255	0.12807989
13.300	4.27070809	4.26792813	0.00277996	0.00000772
13.460	4.04587079	4.27317334	-0.22730258	0.05166645
12.610	4.13499833	4.24530507	-0.11030675	0.01216757
14.930	4.93814660	4.32136918	0.61677754	0.38041442
13.750	4.21539880	4.28268147	-0.06728269	0.00452695
13.515	4.41685010	4.27497674	0.14187338	0.02012805
12.260	4.54510403	4.23383046	0.31127363	0.09689123
12.740	4.71500302	4.24956704	0.46543604	0.21663066
13.110	4.58839226	4.26169873	0.32669359	0.10672867
13.390	3.33778238	4.27087880	-0.93309605	0.87066805
13.390	4.26561929	4.27087880	-0.00525951	0.00002766
11.300	3.94801521	4.20235539	-0.25433975	0.06468868
10.240	4.21861268	4.16760159	0.05101109	0.00260213
14.090	4.47478772	4.29382897	0.18095877	0.03274606
15.220	4.68794823	4.33087731	0.35707098	0.12749967
11.340	4.54433251	4.20366669	0.34066587	0.11605320
16.160	4.44794083	4.36169625	0.08624459	0.00743812
11.820	4.66881371	4.21940423	0.44940954	0.20196890
9.320	3.86270142	4.13743878	-0.27473694	0.07548035
9.290	4.03221894	4.13645554	-0.10423661	0.01086527
11.030	4.00257397	4.19350339	-0.19092944	0.03645404
11.090	3.79697514	4.19546986	-0.39849430	0.15879768
27.780	4.95876599	4.74267197	0.21609404	0.04669662
21.100	5.64337350	4.52365971	1.11971402	1.25375914
25.120	4.79504586	4.65546037	0.13958552	0.01948411
18.780	5.61023999	4.44759560	1.16264462	1.35174203
26.660	5.46754838	4.70595074	0.76159775	0.58003103
23.470	5.61686707	4.60136319	1.01550412	1.03124833
27.480	4.72407628	4.73283578	-0.00875950	0.00007672
22.820	4.21325112	4.58005238	-0.36680132	0.13454318
18.780	4.71760369	4.44759560	0.27000814	0.07290437
25.950	5.73626328	4.68267251	1.05359101	1.11005354
30.620	4.83970643	4.83578397	0.00392246	0.00001538
37.770	4.42035199	5.07020569	-0.64985382	0.42230987
39.190	5.14023686	5.11676217	0.02347469	0.00055106
12.310	3.88235426	4.23546983	-0.35311514	0.12469026
11.370	3.73243618	4.20464993	-0.47221332	0.22298538
11.370	4.55330087	4.20464993	0.34865099	0.12155747

Exhibit 6.1
(Cont... 5)

12.310	4.39467621	4.23546983	0.15920642	0.02534667
11.830	4.09949208	4.21973229	-0.12024022	0.01445771
11.430	3.92914677	4.20661736	-0.27747017	0.07698966
12.200	3.95731735	4.23186303	-0.27454525	0.07537506
7.810	3.80778599	4.08793164	-0.28014522	0.07848131
9.040	4.28981400	4.12825871	0.16155532	0.02610011
8.100	4.01663399	4.09743977	-0.08080579	0.00652957
7.920	4.49689294	4.09153844	0.40535456	0.16431227
8.380	4.09344960	4.10661984	-0.01317024	0.00017345
7.550	3.86015368	4.07940674	-0.21925261	0.04807169
6.610	3.36116266	4.04858781	-0.68742478	0.47255271
7.160	3.55185223	4.06662083	-0.51476824	0.26498627
6.500	4.05640889	4.04498196	0.01142692	0.00013057
6.610	4.27239895	4.04858781	0.22381117	0.05009143
12.990	4.40626813	4.25776387	0.14850428	0.02205351
12.990	4.36278249	4.25776387	0.10501863	0.01102891
12.260	4.87914849	4.23383046	0.64531815	0.41643536
12.260	3.64146471	4.23383046	-0.59236538	0.35089665
12.730	4.73689748	4.24923993	0.48765760	0.23780989
11.704	4.96385480	4.21560097	0.74825394	0.55988383
17.550	3.81848097	4.40726853	-0.58878719	0.34667027
19.270	4.51693345	4.46366120	0.05327225	0.00283793
19.145	4.14079571	4.45956326	-0.31876760	0.10161276
21.510	4.39317990	4.53710271	-0.14392283	0.02071377
17.450	4.74007703	4.40399075	0.33608633	0.11295399
12.840	4.29577161	4.25284577	0.04292584	0.00184262
12.700	4.17489053	4.24825574	-0.07336522	0.00538245
17.540	3.99813938	4.40694142	-0.40880161	0.16711872
19.170	4.82814599	4.46038247	0.36776357	0.13525003
17.450	4.23452855	4.40399075	-0.16946223	0.02871743
12.580	3.88235426	4.24432183	-0.36196714	0.13102018
19.300	4.50415326	4.46464444	0.03950882	0.00156094
11.580	4.36740208	4.21153546	0.15586665	0.02429440
11.910	4.16703797	4.22235490	-0.05531693	0.00305996
24.460	4.57100011	4.63382149	-0.06282140	0.00394652
21.060	3.42779970	4.52234841	-1.09454846	1.19803595
21.020	4.48876286	4.52103711	-0.03227425	0.00104162
21.060	4.46814347	4.52234841	-0.05420494	0.00293817
20.980	4.59917164	4.51972581	0.07944585	0.00631164
21.050	5.04037762	4.52202035	0.51835739	0.26869428
21.110	4.11146832	4.52398778	-0.41251951	0.17017230
18.290	4.74007703	4.43153096	0.30854612	0.09520068
20.930	4.32022286	4.51808644	-0.19786360	0.03914999
23.750	3.85503864	4.61054326	-0.75550425	0.57078659
20.950	4.23663140	4.51874162	-0.28211027	0.07958617
21.850	3.58598519	4.54824925	-0.96226370	0.92595124
22.120	4.70453168	4.55710221	0.14742949	0.02173544
22.200	4.77848340	4.55972481	0.21875861	0.04785532
22.480	3.69703436	4.56890488	-0.87187016	0.76015746
8.410	4.27913285	4.10760308	0.17152980	0.02942246
8.400	3.69402695	4.10727502	-0.41324764	0.17077359
8.400	4.47230149	4.10727502	0.36502653	0.13324433
8.400	4.03092957	4.10727502	-0.07634545	0.00582862

SDLWH= 0.00213813 SDLWH2= 19.30414586

Exhibit 6.1
(Cont... 6)

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
DUE TO LNA	1.	2081.92969417	2081.92969417
DUE TO LNB/LNA	1.	4.94072438	4.94072438
RESIDUAL	108.	19.30414586	0.17874208

VARIANCE ESTIMATES

VAR OF ERRORS OF ESTIMATE	VARIANCE FOR LNA	VARIANCE FOR LNB
0.17874208	0.01135477	0.00003888

CONFIDENCE LIMITS

80909599 TPRDF	FOR LNA LOWER	FOR LNA UPPER	FOR LNB LOWER	FOR LNB UPPER
1.290	3.69441032	3.96933222	0.02474168	0.04083068
1.661	3.65487719	4.00886536	0.02242811	0.04314425
1.982	3.62067175	4.04307080	0.02042634	0.04514603
2.625	3.55215454	4.11158848	0.01641656	0.04915580

TEST-OF-HYPOTHESES PARAMETERS FOR LNB
(WITH THE HYPOTHESIS THAT LNB=0)

T = 5.25752831 F = 27.64164356

EXHIBIT 6.2

Some Results from the Analysis of the Ponce Private Urbanization Areas Data

UNIVERSITY OF PUERTO RICO
WATER RESOURCES RESEARCH INSTITUTE
MAYAGUEZ, PUERTO RICO

OUTPUT OF EXPONENTIAL REGRESSION-MODEL ANALYSIS PROGRAM

EXPONENTIAL REGRESSION-MODEL ANALYSIS FOR SOME SELECTED DWELLING CHARACTERISTICS WITH, ANALYSIS OF VARIANCE, REGRESSION PLOTBACK, VARIANCE ESTIMATES FOR MODEL PARAMETERS CONFIDENCE INTERVALS, AND TESTS OF HYPOTHESES. PROFESSOR A. GUILBE, INDUSTRIAL ENGINEERING DEPARTMENT/WATER RESOURCES RESEARCH INSTITUTE.

RESIDENTIAL WATER-USE PROJECT
MAIN PONCE URBANIZATION DWELLINGS
SOME SELECTED DWELLING CHARACTERISTICS

INDIVIDUAL DWELLING I.D.	PROPERTY VALUE IN DOLLARS	PER DWELLING DAILY USE IN GALLONS FOR			PER CAPITA DAILY USE IN GALLONS FOR		
		MINMO	AVEMO	MAXMO	MINMO	AVEMO	MAXMO
-808 -3	5060.	322.	396.	444.	35.	44.	49.
-808-10	5060.	148.	200.	270.	21.	28.	38.
-808 -1	5060.	270.	313.	348.	67.	78.	87.
-808 -5	5060.	130.	209.	279.	43.	69.	93.
-808 -2	5150.	148.	162.	183.	29.	32.	36.
-805-10	5480.	244.	265.	287.	48.	53.	57.
-808 -4	5560.	183.	236.	296.	30.	39.	49.
-808 -8	5700.	200.	241.	261.	25.	30.	32.
-808 -6	5830.	156.	329.	462.	26.	54.	77.
-805 -6	6960.	148.	347.	427.	37.	86.	106.
-808 -7	7020.	331.	369.	427.	55.	61.	71.
-805 -2	7580.	217.	236.	270.	54.	59.	67.
-804 -8	7740.	130.	300.	688.	21.	50.	114.
-804 -9	7740.	87.	127.	165.	29.	42.	55.
-804-10	7740.	130.	161.	200.	43.	53.	66.
-804 -3	7780.	78.	119.	200.	39.	59.	100.
-805 -9	7810.	43.	77.	130.	14.	25.	43.
-801-20	7830.	270.	295.	340.	54.	59.	68.
-804 -1	7890.	279.	322.	401.	55.	64.	80.
-804 -5	7890.	462.	514.	549.	66.	73.	78.
-804 -6	7890.	322.	334.	357.	80.	83.	89.
-801-21	7900.	366.	488.	653.	91.	122.	163.
-801-23	7900.	313.	404.	497.	52.	67.	82.
-801-24	7900.	261.	287.	357.	52.	57.	71.
-801-14	7910.	104.	120.	139.	26.	30.	34.
-801 -7	7970.	34.	85.	113.	11.	28.	37.
-801-13	8010.	130.	159.	183.	32.	39.	45.
-805 -1	8010.	296.	360.	435.	59.	72.	87.
-801 -5	8010.	191.	222.	191.	47.	55.	47.
-801 -6	8020.	261.	265.	331.	37.	37.	47.

-801-12	8040.	139.	202.	279.	46.	67.	93.
-801 -9	8080.	270.	360.	435.	67.	90.	108.
-804 -4	8180.	357.	373.	435.	59.	62.	72.
-804 -7	8210.	209.	264.	313.	41.	52.	62.
-801-16	8240.	209.	242.	279.	34.	40.	46.
-801-18	8250.	374.	459.	584.	62.	76.	97.
-801-17	8310.	78.	107.	122.	19.	26.	30.
-801-15	8550.	322.	326.	357.	80.	81.	89.
-801-10	8950.	279.	324.	366.	55.	64.	73.
-801 -8	9000.	313.	356.	401.	62.	71.	80.
-803 -2	9070.	200.	255.	313.	66.	85.	104.
-806-12	9120.	401.	431.	488.	66.	71.	81.
-806-11	9120.	139.	162.	174.	27.	32.	34.
-806 -4	9130.	383.	412.	488.	127.	137.	162.
-806 -5	9150.	540.	572.	671.	77.	81.	95.
-806 -2	9260.	174.	196.	217.	43.	49.	54.
-806 -9	9330.	235.	382.	601.	47.	76.	120.
-801 -1	9400.	540.	637.	898.	77.	91.	128.
-806 -8	9540.	497.	550.	688.	99.	110.	137.
-801-19	9770.	444.	537.	723.	88.	107.	144.
-801-22	10050.	305.	356.	401.	61.	71.	80.
-806-15	10230.	87.	401.	462.	17.	80.	92.
-806-14	10230.	261.	377.	592.	87.	125.	197.
-806-13	10230.	226.	290.	366.	113.	145.	183.
-805 -8	10340.	148.	187.	217.	49.	62.	72.
-801 -4	10550.	174.	194.	235.	58.	64.	78.
-801 -2	10550.	340.	372.	401.	56.	62.	66.
-801 -3	10560.	252.	276.	296.	50.	55.	59.
-804 -2	10700.	348.	382.	409.	87.	95.	102.
-805 -7	10820.	156.	206.	252.	78.	103.	126.
-806 -6	10830.	95.	129.	165.	23.	32.	41.
-806 -3	11030.	409.	504.	558.	58.	72.	79.
-806 -7	11180.	191.	220.	244.	95.	110.	122.
-805 -4	11280.	322.	373.	488.	80.	93.	122.
-801-11	11460.	653.	787.	959.	72.	87.	106.
-805 -5	11670.	191.	324.	453.	31.	54.	75.
-803 -4	12070.	191.	225.	296.	38.	45.	59.
-806 -1	12280.	427.	478.	558.	71.	79.	93.
-806-10	12300.	183.	217.	244.	45.	54.	61.
-803 -5	12390.	130.	156.	200.	43.	52.	66.
-805 -3	12470.	226.	373.	514.	75.	124.	171.
-807 -1	13750.	130.	174.	200.	65.	87.	100.
-803 -3	14120.	183.	207.	287.	45.	51.	71.
-807 -6	14120.	270.	482.	653.	45.	80.	108.
-807 -9	14240.	95.	302.	418.	15.	50.	69.
-807 -2	14370.	209.	367.	497.	52.	91.	124.
-807-10	14440.	732.	870.	976.	122.	145.	162.
-803 -1	14720.	357.	382.	409.	59.	63.	68.
-807 -8	15070.	252.	310.	357.	126.	155.	178.
-809 -1	15860.	113.	168.	235.	28.	42.	58.
-802 -1	15870.	165.	219.	296.	23.	31.	42.
-807 -4	15940.	558.	587.	636.	111.	117.	127.
-807 -3	15990.	837.	1438.	2240.	209.	359.	560.
-802 -8	15990.	313.	382.	566.	62.	76.	113.
-802 -6	16110.	113.	175.	252.	22.	35.	50.
-802-11	16640.	130.	226.	305.	32.	56.	76.

Exhibit 6.2
(Cont... 2)

-807 -7	16990.	279.	367.	540.	69.	91.	135.
-802 -3	18130.	409.	485.	566.	58.	69.	80.
-802 -4	20050.	165.	318.	514.	82.	159.	257.
-802 -7	20140.	549.	675.	810.	91.	112.	135.
-802 -2	20530.	217.	271.	331.	36.	45.	55.
-802 -5	21480.	226.	313.	444.	45.	62.	88.
-802-12	21890.	191.	402.	706.	38.	80.	141.
-802 -9	22210.	662.	986.	1429.	110.	164.	238.
-807 -5	23320.	418.	542.	627.	69.	90.	104.

KSELEC= 5

REGRESSION COMPUTATIONAL ELEMENTS

N= 95.

V=	1033.34741497	SLNW=	399.22668528		
VEV=	10.87734034	AVELNW=	4.20238591		
V2=	12979.54103851	SLNW2=	1698.41772747	SVTLNW=	4409.32716178
SMV=	11240.06838226	SSMLNW=	1677.70434904	SSMVLW=	4342.52344894
SSV=	1739.47290325	CSSLNW=	20.71338276	CSSVLW=	66.80372640

LNA= 3.78464556 LNB= 0.03840458

THE CORRESPONDING REGRESSION MODEL IS

LNW= 3.78464556 + 0.03840458* V IN REDUCED FORM

W = 44.02005015 * 1.03915167 ** V IN EXPONENTIAL FORM

REGRESSION PLOTBACK

V	LNW	LNWH	DLWH	DLWH2
5.060	3.78604555	3.97897244	-0.19292691	0.03722078
5.060	3.35514212	3.97897244	-0.62383043	0.38916426
5.060	4.36278249	3.97897244	0.38380962	0.14730981
5.060	4.24499989	3.97897244	0.26602703	0.07077035
5.150	3.48285961	3.98242903	-0.49956947	0.24956962
5.480	3.97384644	3.99510241	-0.02125597	0.00045181
5.560	3.67578936	3.99817467	-0.32238537	0.10393229
5.700	3.40634489	4.00355149	-0.59720623	0.35665518
5.830	4.00698949	4.00854398	-0.00155448	0.00000241
6.960	4.46396733	4.05194092	0.41202646	0.16976577
7.020	4.11937333	4.05424595	0.06512738	0.00424157
7.580	4.08125497	4.07575227	0.00550270	0.00003027
7.740	3.91475773	4.08189679	-0.16713860	0.02793530
7.740	3.75252295	4.08189679	-0.32937342	0.10848681
7.740	3.98471642	4.08189679	-0.09717990	0.00944393
7.780	4.08737088	4.08343316	0.00393772	0.00001550

Exhibit 6.2
(Cont... 3)

7.810	3.25486803	4.08458520	-0.82971680	0.68842983
7.830	4.07756711	4.08535386	-0.00778675	0.00006063
7.890	4.16703797	4.08765793	0.07938005	0.00630119
7.890	4.29718591	4.08765793	0.20952799	0.04390197
7.890	4.42558385	4.08765793	0.33792597	0.11419393
7.900	4.80461503	4.08804131	0.71657383	0.51347792
7.900	4.20966054	4.08804131	0.12161923	0.01479123
7.900	4.05262757	4.08804131	-0.03541374	0.00125413
7.910	3.40634489	4.08842564	-0.68208038	0.46523350
7.970	3.35272360	4.09072972	-0.73800575	0.54465234
8.010	3.68798447	4.09226609	-0.40428119	0.16344326
8.010	4.27778912	4.09226609	0.18552306	0.03441879
8.010	4.01794244	4.09226609	-0.07432366	0.00552400
8.020	3.63737440	4.09265042	-0.45527559	0.20727583
8.040	4.20966054	4.09341813	0.11624242	0.01351229
8.080	4.50093366	4.09495450	0.40597921	0.16481909
8.180	4.13111497	4.09879494	0.03232003	0.00104458
8.210	3.96836710	4.09994698	-0.13157942	0.01731314
8.240	3.70003319	4.10109902	-0.40106540	0.16085341
8.250	4.33778096	4.10148335	0.23629763	0.05583656
8.310	3.29156923	4.10378743	-0.81221783	0.65969765
8.550	4.40360451	4.11300469	0.29059988	0.08444826
8.950	4.17153264	4.12836648	0.04316616	0.00186331
9.000	4.26561833	4.13028718	0.13533118	0.01831452
9.070	4.44567014	4.13297463	0.31269556	0.09777848
9.120	4.27577115	4.13489533	0.14087584	0.01984599
9.120	3.48285961	4.13489533	-0.65203535	0.42514997
9.130	4.92416097	4.13527966	0.78888142	0.62233376
9.150	4.40423966	4.13604737	0.26819235	0.07192711
9.260	3.89277887	4.14027215	-0.24749282	0.06125268
9.330	4.33651448	4.14296055	0.19355395	0.03746312
9.400	4.51238824	4.14564896	0.36673933	0.13449770
9.540	4.70189668	4.15102482	0.55087196	0.30345982
9.770	4.67786313	4.15985776	0.51800549	0.26832962
10.050	4.26561833	4.17061139	0.09500695	0.00902632
10.230	4.38476182	4.17752457	0.20723727	0.04294727
10.230	4.83586789	4.17752457	0.65834343	0.43341595
10.230	4.97896863	4.17752457	0.80144417	0.64231264
10.340	4.13499928	4.18174840	-0.04674912	0.00218548
10.550	4.17302609	4.18981362	-0.01678753	0.00028182
10.550	4.12721635	4.18981362	-0.06259728	0.00391841
10.560	4.01138497	4.19019795	-0.17881301	0.03197408
10.700	4.55965806	4.19557477	0.36408335	0.13255664
10.820	4.63647843	4.20018292	0.43629556	0.19035378
10.830	3.47614050	4.20056725	-0.72442639	0.52479350
11.030	4.27721310	4.20824815	0.06896497	0.00475616
11.180	4.70453168	4.21400834	0.49052339	0.24061316
11.280	4.53658009	4.21784879	0.31873136	0.10158965
11.460	4.47183991	4.22476197	0.24707797	0.06104751
11.670	3.98921061	4.23282719	-0.24361613	0.05934880
12.070	3.80778599	4.24818898	-0.44040256	0.19395437
12.280	4.37809659	4.25625325	0.12184335	0.01484579
12.300	3.99813938	4.25702191	-0.25888210	0.06701992
12.390	3.95731735	4.26047803	-0.30316025	0.09190611
12.470	4.82426263	4.26355076	0.56071198	0.31439781
13.750	4.46814347	4.31270886	0.15543463	0.02415991

Exhibit 6.2
(Cont... 4)

14.120	3.95034886	4.32691861	-0.37656933	0.14180442
14.120	4.38717366	4.32691861	0.06025505	0.00363067
14.240	3.91957712	4.33152676	-0.41194921	0.16970211
14.370	4.52089406	4.33651925	0.18437483	0.03399407
14.440	4.97730065	4.33920766	0.63809311	0.40716272
14.720	4.15419293	4.34996129	-0.19576838	0.03832525
15.070	5.04662801	4.36340237	0.68322575	0.46679729
15.860	3.74109459	4.39374257	-0.65264761	0.42594879
15.870	3.44516802	4.39412595	-0.94895756	0.90052032
15.940	4.76577569	4.39681435	0.36896139	0.13613247
15.990	5.88520909	4.39873505	1.48647427	2.20960522
15.990	4.33651448	4.39873505	-0.06222058	0.00387139
16.110	3.56015110	4.40334321	-0.84319174	0.71097219
16.640	4.03736020	4.42369748	-0.38633734	0.14925649
16.990	4.52089406	4.43713952	0.08375455	0.00701482
18.130	4.23902989	4.48092080	-0.24189093	0.05851121
20.050	5.06972314	4.55465699	0.51506626	0.26529318
20.140	4.72407628	4.55811406	0.16596224	0.02754345
20.530	3.81314755	4.57309151	-0.75994360	0.57751417
21.480	4.13963891	4.60957623	-0.46993738	0.22084111
21.890	4.38837815	4.62532140	-0.23694327	0.05614210
22.210	5.10266019	4.63761140	0.46504885	0.21627038
23.320	4.50361729	4.68024064	-0.17662337	0.03119580

SDLWH= 0.00153780 SDLWH2= 18.14308170

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
DUE TO LNA	1.	1677.70434904	1677.70434904
DUE TO LNB/LNA	1.	2.56556845	2.56556845
RESIDUAL	93.	18.14308170	0.19508686

VARIANCE ESTIMATES

VAR OF ERRORS OF ESTIMATE	VARIANCE FOR LNA	VARIANCE FOR LNB
0.19508686	0.01532308	0.00011215

Exhibit 6.2
(Cont... 5)

CONFIDENCE LIMITS

80909599 TPRDF	FOR LNA LOWER	FOR LNA UPPER	FOR LNB LOWER	FOR LNB UPPER
1.291	3.62483692	3.94445372	0.02473258	0.05207657
1.662	3.57891226	3.99037838	0.02080361	0.05600554
1.987	3.53868151	4.03060914	0.01736178	0.05944737
2.632	3.45883942	4.11045171	0.01053108	0.06627807

TEST-OF-HYPOTHESES PARAMETERS FOR LNB
(WITH THE HYPOTHESIS THAT LNB=0)

T = 3.62641573 F = 13.15090372

Exhibit 6.2
(Cont... 6)

Exhibit 6.2
(Cont... 7)

KSELEC= 2

REGRESSION COMPUTATIONAL ELEMENTS

N=	95.				
V=	1033.34741497	SLNW=	542.14270162		
VEV=	10.87734034	AVELNW=	5.70676423		
V2=	12979.54103851	SLNW2=	3118.59131431	SVTLNW=	5964.23731803
SMV=	11240.06838226	SSMLNW=	3093.87988853	SSMVLW=	5897.06934928
SSV=	1739.47290325	CSSLNW=	24.71142964	CSSVLW=	67.16798418

LNA= 5.28674603 LNB= 0.03861399

THE CORRESPONDING REGRESSION MODEL IS

LNW= 5.28674603 + 0.03861399* V IN REDUCED FORM

W = 197.69888347 * 1.03936934 ** V IN EXPONENTIAL FORM

REGRESSION PLOTBACK

V	LNW	LNWH	DLWH	DLWH2
5.060	5.98326970	5.48213197	0.50113785	0.25113904
5.060	5.30105210	5.48213197	-0.18107989	0.03278992
5.060	5.74907685	5.48213197	0.26694494	0.07125957
5.060	5.34361173	5.48213197	-0.13852027	0.01918786
5.150	5.09229756	5.48560715	-0.39330965	0.15469244
5.480	5.58328438	5.49835015	0.08493424	0.00721382
5.560	5.46754838	5.50143910	-0.03389073	0.00114858
5.700	5.48578645	5.50684548	-0.02105904	0.00044348
5.830	5.79874898	5.51186467	0.28688436	0.08230261
6.960	5.85026169	5.55549908	0.29476267	0.08688500
7.020	5.91113282	5.55781556	0.35331732	0.12483309
7.580	5.46754838	5.57943917	-0.11189080	0.01251954
7.740	5.70651723	5.58561803	0.12089921	0.01461661
7.740	4.85113526	5.58561803	-0.73448288	0.53946495
7.740	5.08332921	5.58561803	-0.50228893	0.25229406
7.780	4.78051759	5.58716202	-0.80664456	0.65067529

7.810	4.35348035	5.58832074	-1.23484063	1.52483082
7.830	5.68700410	5.58909322	0.09791089	0.00958654
7.890	5.77647591	5.59140969	0.18506625	0.03424951
7.890	6.24309540	5.59140969	0.65168583	0.42469430
7.890	5.81187821	5.59140969	0.22046855	0.04860637
7.900	6.19090939	5.59179593	0.59911358	0.35893696
7.900	6.00141908	5.59179593	0.40962320	0.16779112
7.900	5.66206551	5.59179593	0.07026959	0.00493781
7.910	4.79263878	5.59218217	-0.79954350	0.63926971
7.970	4.45133591	5.59449864	-1.14316296	1.30682111
8.010	5.07427884	5.59604359	-0.52176487	0.27223849
8.010	5.88722706	5.59604359	0.29118353	0.08478781
8.010	5.40423680	5.59604359	-0.19180682	0.03678984
8.020	5.58328438	5.59642983	-0.01314544	0.00017280
8.040	5.30827237	5.59720231	-0.28892999	0.08348052
8.080	5.88722706	5.59874631	0.28848081	0.08322115
8.180	5.92287446	5.60260774	0.32026678	0.10257078
8.210	5.57780553	5.60376645	-0.02596092	0.00067396
8.240	5.49179269	5.60492516	-0.11313249	0.01279895
8.250	6.12954045	5.60531045	0.52423012	0.27481710
8.310	4.67786408	5.60762788	-0.92976391	0.86446082
8.550	5.78989888	5.61689473	0.17300418	0.02993043
8.950	5.78097058	5.63234044	0.14863017	0.02209091
9.000	5.87505627	5.63427163	0.24078467	0.05797725
9.070	5.54428292	5.63697434	-0.09269143	0.00859170
9.120	6.06753064	5.63890458	0.42862612	0.18372032
9.120	5.09229756	5.63890458	-0.54660713	0.29877925
9.130	6.02277280	5.63929082	0.38348203	0.14705845
9.150	6.35014916	5.64006329	0.71008598	0.50422203
9.260	5.27907372	5.64431096	-0.36523729	0.13339826
9.330	5.94595242	5.64701367	0.29893881	0.08936437
9.400	6.45829774	5.64971734	0.80858051	0.65380227
9.540	6.31133462	5.65512276	0.65621197	0.43061405
9.770	6.28730107	5.66400433	0.62329685	0.38849884
10.050	5.87505627	5.67481614	0.20024016	0.04009611
10.230	5.99419881	5.68176652	0.31243234	0.09761394
10.230	5.93447972	5.68176652	0.25271326	0.06386396
10.230	5.67211629	5.68176652	-0.00965023	0.00009312
10.340	5.23361111	5.68601418	-0.45240312	0.20466855
10.550	5.27163792	5.69412327	-0.42248541	0.17849388
10.550	5.91897584	5.69412327	0.22485259	0.05055867
10.560	5.62082291	5.69450951	-0.07368661	0.00542971
10.700	5.94595242	5.69991494	0.24603751	0.06053444
10.820	5.32962514	5.70454884	-0.37492376	0.14056780
10.830	4.86243439	5.70493508	-0.84250080	0.70980751
11.030	6.22312356	5.71265793	0.51046574	0.26057517
11.180	5.39767934	5.71844960	-0.32077032	0.10289357
11.280	5.92287446	5.72231103	0.20056346	0.04022569
11.460	6.66906453	5.72926140	0.93980324	0.88322997
11.670	5.78097058	5.73737050	0.04360008	0.00190096
12.070	5.41722394	5.75281621	-0.33559233	0.11262217
12.280	6.16985608	5.76092530	0.40893083	0.16722440
12.300	5.38443375	5.76169778	-0.37726408	0.14232814
12.390	5.05593014	5.76517296	-0.70924294	0.50302541
12.470	5.92287446	5.76826192	0.15461257	0.02390503
13.750	5.16129017	5.81768799	-0.65639794	0.43085813

Exhibit 6.2
(Cont... 8)

14.120	5.33664323	5.83197499	-0.49533182	0.24535357
14.120	6.17893315	5.83197499	0.34695822	0.12037996
14.240	5.71133710	5.83660889	-0.12527182	0.01569302
14.370	5.90718747	5.84162808	0.06555940	0.00429803
14.440	6.76906014	5.84433175	0.92472851	0.85512268
14.720	5.94595242	5.85514355	0.09080888	0.00824625
15.070	5.73977471	5.86865807	-0.12888339	0.01661092
15.860	5.12738896	5.89916325	-0.77177441	0.59563565
15.870	5.39107800	5.89954949	-0.50847160	0.25854331
15.940	6.37521363	5.90225220	0.47296148	0.22369253
15.990	7.27150345	5.90418339	1.36732030	1.86956429
15.990	5.94595242	5.90418339	0.04176903	0.00174465
16.110	5.16958905	5.90881634	-0.73922741	0.54645705
16.640	5.42365456	5.92928220	-0.50562775	0.25565934
16.990	5.90718747	5.94279671	-0.03560925	0.00126801
18.130	6.18493939	5.98681737	0.19812205	0.03925234
20.050	5.76287079	6.06095601	-0.29808527	0.08885480
20.140	6.51583577	6.06443120	0.45140463	0.20376610
20.530	5.60490704	6.07949067	-0.47458368	0.22522962
21.480	5.74907685	6.11617375	-0.36709696	0.13476014
21.890	5.99781609	6.13200570	-0.13418963	0.01800685
22.210	6.89441968	6.14436246	0.75005734	0.56258595
23.320	6.29537679	6.18722344	0.10815335	0.01169714

SDLWH= 0.00209140 SDLWH2= 22.10810093

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
DUE TO LNA	1.	3093.87988853	3093.87988853
DUE TO LNB/LNA	1.	2.59362316	2.59362316
RESIDUAL	93.	22.10810093	0.23772150

VARIANCE ESTIMATES

VAR OF ERRORS OF ESTIMATE	VARIANCE FOR LNA	VARIANCE FOR LNB
0.23772150	0.01867181	0.00013666

CONFIDENCE LIMITS

FOR LNA FOR LNB

Exhibit 6.2
(Cont... 9)

80909599

TPRDF	LOWER	UPPER	LOWER	UPPER
1.291	5.11033727	5.46315385	0.02352180	0.05370616
1.662	5.05964185	5.51384926	0.01918470	0.05804326
1.987	5.01523209	5.55825902	0.01538535	0.06184261
2.632	4.92709637	5.64639474	0.00784511	0.06938286

TEST-OF-HYPOTHESES PARAMETERS FOR LNB
(WITH THE HYPOTHESIS THAT LNB=0)

T = 3.30307913 F = 10.91034319

Exhibit 6.2
(Cont... 10)

6.2 Comparative Summary of Model Parameters

The fore mentioned analyses of the samples collected in San Juan and Ponce for the present study, together with that previously conducted in Mayaguez, yielded estimates of the corresponding model parameters for each area.

Table 6.3 summarizes these results for the equivalent months of average and maximum water usage.

6.3 Comparative Summary of the Sums of Differences in Regression Plot backs

Each of the previously stated analyses contained a regression plot back table. These tables were generated with the objective of observing the differences between each actual water-use datum and its estimate, as yielded by the corresponding model. These differences (simple and squared) form the basis for the determination of the variance of errors of estimate (S_E^2), a very important parameter in analysis-of-variance.

Table 6.4 summarizes these differences for the three areas under study.

6.4 Comparative Summary of the analysis-of-Variance Conducted

As in the previous study for the Mayaguez area, analysis-of-variance tables (ANOVA) were assembled for San Juan and Ponce.

Tables 6.5 to 6.8 present the assembled values. These are used in the estimation of test parameters and the variances of the corresponding model parameters.

TABLE 6.3

Comparative summary of Model Parameter Values for the Equivalent Months of Average and Maximum Water Use

Private Urbanization Dwellings

Water System Design Index	Equivalent Month	Parameters					
		LNA (α_L)			LNB (k)		
		San Juan	Ponce	Maya-guez	San Juan	Ponce	Maya-guez
gpcd	AVEMO	3.832	3.887	3.522	0.0328	0.0287	0.0455
	MAXMO	4.121	4.028	3.788	0.0312	0.0364	0.0427
gpd	AVEMO	5.205	5.311	4.925	0.0352	0.0349	0.0399
	MAXMO	5.494	5.452	5.191	0.0336	0.0426	0.0371

TABLE 6.4

Comparative Summary of the Sums of Differences in Regression Plotbacks

Water System Design Index	Equivalent Month	Simple Difference $\Sigma (W_L-\hat{W}_L)$ (SDLWH in Analysis)			Squared Difference $\Sigma (W_L-\hat{W}_L)^2$ (SDLWH2 in Analysis)		
		San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez
gpcd	AVEMO	0.00214	0.00154	0.000248	19.304	18.143	2.412
	MAXMO	0.00225	0.00148	0.000226	23.957	19.704	4.330
gpd	AVEMO	0.00315	0.00209	0.000635	18.885	22.108	6.068
	MAXMO	0.00336	0.00222	0.000681	22.648	22.452	7.450

6.5 Comparative Summary for Model Parameter Variance Estimates

Based on the results of the preceeding ANOVA tables, model parameter variances were estimated. These estimates are useful in determining within which limits the true model parameters are expected to lie. Equations 6.2 and 6.3 were used to estimate the variances for α_L and k respectively (4).

$$VAR (\alpha_L) = S_E^2 (1/N + \bar{V}^2/\Sigma V^2) \quad (6.2)$$

$$VAR (k) = S_E^2 / \Sigma V^2 \quad (6.3)$$

where S_E^2 is the variance of errors of estimate and $\bar{V}$ the average property value of a sample of N dwellings. (Table 6.9)

TABLE 6.5

Comparative ANOVA Table for gpcd in AVEMO

Source of Variation	Degrees of Freedom			Sum of Squares			Mean Square		
	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez
Due to α_L	1	1	1	2081.930	1677.704	824.324	2081.930	1677.704	824.324
Due to k/α_L	1	1	1	4.941	2.566	4.477	4.941	2.566	4.477
Residual	108	93	46	19.304	18.143	2.412	0.179	0.195	0.052

TABLE 6.6

Comparative ANOVA Table for gpcd in MAXMO

Source of Variation	Degrees of Freedom			Sums of Squares			Mean Square		
	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez
Due to α_L	1	1	1	2341.626	1860.214	917.530	2341.626	1860.214	917.530
Due to k/α_L	1	1	1	4.468	3.770	3.943	4.468	3.770	3.943
Residual	108	93	46	23.957	19.704	4.330	0.222	0.212	0.094

TABLE 6.7

Comparative ANOVA Table for gpd in AVEMO

Source of Variation	Degrees of Freedom			Sums of Squares			Mean Square		
	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez
Due to α_L	1	1	1	3652.594	3093.880	1436.286	3652.594	3093.880	1436.286
Due to k/α_L	1	1	1	5.707	2.594	3.445	5.707	2.594	3.445
Residual	108	93	46	18.885	22.108	6.068	0.175	0.238	0.132

TABLE 6.8

Comparative ANOVA Table for gpd in MAXMO

Source of Variation	Degrees of Freedom			Sums of Squares			Mean Square		
	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez
Due to α_L	1	1	1	3394.097	3340.036	1558.518	3394.097	3340.036	1558.518
Due to k/α_L	1	1	1	5.198	3.804	2.978	5.198	3.804	2.978
Residual	108	93	46	22.648	22.452	7.450	0.210	0.241	0.162

TABLE 6.9

Comparative Summary for Model

Parameter Variance Estimates

Water System Design Index	Equivalent Month	Variance for α_L			Variance for k			Variance of Errors-of-Estimate		
		San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez
gpcd	AVEMO	0.0114	0.0153	0.0056	$3.89x10^{-5}$	$11.22x10^{-5}$	$2.43x10^{-5}$	0.179	0.195	0.052
	MAXMO	0.0141	0.0166	0.0101	$4.83x10^{-5}$	$12.18x10^{-5}$	$4.35x10^{-5}$	0.222	0.212	0.094
gpd	AVEMO	0.0111	0.0187	0.0141	$3.80x10^{-5}$	$13.67x10^{-5}$	$6.10x10^{-5}$	0.175	0.238	0.132
	MAXMO	0.0133	0.0190	0.0174	$4.56x10^{-5}$	$13.88x10^{-5}$	$7.49x10^{-5}$	0.210	0.241	0.162

6.6 Comparative Summary of Confidence Limits for Model Parameters

The limits within which the true values of the model parameters are expected to lie were estimated for several confidence levels. Equation 6.4 is a composite of the formulas employed to estimate these limits

$$\left.\begin{array}{l} C.L.\alpha_L = \alpha_L \\ C.L._k = k \end{array}\right\} \pm\, t_{\underline{P}}\ (N-2)\ \sqrt{VAR\left(\quad\right)} \left\{\begin{array}{l} \alpha_L \\ k \end{array}\right. \tag{6.4}$$

$$\text{where } P = (1+\ ')/2 \tag{6.5}$$

C.L. stands for "confidence limits"; γ' is the confidence level; t is the t-Distribution factor for γ' and (N-2) degrees of freedom.

Tables 6.10 to 6.13 present comparative summaries for the estimated confidence limits.

6.7 Comparative Summary of Tests-of-Hypothesis for Individual Model Parameters (t-Test)

In order to check the significance of the parameter k, tests of hypothesis were conducted. Their main objective is to verify if the observed correlation between the factor and the response variable is not an accidental result, generated by the random behavior of uncorrelated variables. The hypothesis used to test correlation was that W_L is independent of V (i.e. that V is of no value in predicting W_L if an exponential approximation is used). Stated in other terms, our hypothesis was that the true value for

TABLE 6.10

Comparative Summary of Confidence Limits for Model

Parameters 80% Confidence Level

Water System Design Index	Equivalent Month	Limit	For α_L			For k		
			San Juan 108 D.F. t=1.290	Ponce 93 D.F. t=1.291	Ma aguez 46 D.F. t=1.301	San Juan 108 D.F. t=1.290	Ponce 93 D.F. t=1.291	Mayaguez 46 D.F. t=1.301
gpcd	AVEMO	Upper	3.969	3.944	3.620	0.041	0.052	0.052
		Lower	3.694	3.625	3.425	0.025	0.025	0.039
	MAXMO	Upper	4.274	4.085	3.919	0.040	0.061	0.051
		Lower	3.968	3.752	3.658	0.022	0.032	0.034
gpd	AVEMO	Upper	5.341	5.463	5.079	0.0432	0.054	0.050
		Lower	5.069	5.110	4.770	0.027	0.024	0.030
	MAXMO	Upper	5.643	5.599	5.362	0.042	0.062	0.048
		Lower	5.345	5.243	5.020	0.025	0.032	0.026

TABLE 6.11

Comparative Summary of Confidence Limits for Model Parameters 90% Confidence Level

Water System Design Index	Equivalent Month	Limit	For α_L San Juan 108 D.F. t=1.661	For α_L Ponce 93 D.F. t=1.662	For α_L Mayaguez 46 D.F. t=1.680	For k San Juan 108 D.F. t=1.661	For k Ponce 93 D.F. t=1.662	For k Mayaguez 46 D.F. t=1.680
gpcd	AVEMO	Upper	4.009	3.990	3.648	0.043	0.056	0.054
		Lower	3.655	3.579	3.396	0.022	0.021	0.037
	MAXMO	Upper	4.318	4.133	3.957	0.043	0.065	0.054
		Lower	3.923	3.704	3.620	0.020	0.028	0.032
gpd	AVEMO	Upper	5.380	5.514	5.124	0.045	0.058	0.053
		Lower	5.030	5.060	4.725	0.025	0.019	0.027
	MAXMO	Upper	5.686	5.650	5.412	0.045	0.066	0.052
		Lower	5.302	5.192	4.970	0.022	0.027	0.023

TABLE 6.12

Comparative Summary of Confidence Limits for Model Parameters 95% Confidence Level

Water System Design Index	Equivalent Month	Limit	For α_L San Juan 108 D.F. t=1.982	For α_L Ponce 93 D.F. t=1.987	For α_L Mayaguez 46 D.F. t=2.014	For k San Juan 108 D.F. t=1.982	For k Ponce 93 D.F. t=1.987	For k Mayaguez 46 D.F. t=2.014
gpcd	AVEMO	Upper	4.043	4.031	3.673	0.045	0.059	0.055
		Lower	3.621	3.539	3.371	0.020	0.017	0.036
	MAXMO	Upper	4.356	4.175	3.991	0.045	0.068	0.056
		Lower	3.885	3.662	3.586	0.017	0.025	0.029
gpd	AVEMO	Upper	5.414	5.558	5.164	0.047	0.062	0.056
		Lower	4.996	5.015	4.685	0.023	0.015	0.024
	MAXMO	Upper	5.723	5.694	5.456	0.047	0.070	0.055
		Lower	5.265	5.147	4.926	0.020	0.023	0.020

TABLE 6.13

Comparative Summary of Confidence Limits for Model Parameters 99% Confidence Level

Water System Design Index	Equivalent Month	Limit	For α_L			For k		
			San Juan 108 D.F. t=2.625	Ponce 93 D.F. t=2.632	Mayaguez 46 D.F. t=2.690	San Juan 108 D.F. t=2.625	Ponce 93 D.F. t=2.632	Mayaguez 46 D.F. t=2.690
gpcd	AVEMO	Upper	4.112	4.110	3.724	0.049	0.066	0.059
		Lower	3.552	3.459	3.321	0.016	0.011	0.032
	MAXMO	Upper	4.432	4.258	4.059	0.049	0.076	0.060
		Lower	3.809	3.579	3.518	0.013	0.018	0.025
gpd	AVEMO	Upper	5.482	5.646	5.245	0.051	0.069	0.061
		Lower	4.928	4.927	4.605	0.019	0.008	0.019
	MAXMO	Upper	5.797	5.783	5.545	0.051	0.078	0.060
		Lower	5.191	5.058	4.837	0.016	0.016	0.014

k is zero (0) against the alternative that it is not zero ($\neq 0$). Equotions 6.6, 6.7, 6.8 were used in the computation of the test statistic value and the estimation of the rejection region.

$$t = (k-0) \, / \, \sqrt{VAR\ (k)} \quad (6.6)$$

$$t_c \geq t_{(1-\alpha'/2);\ (N-2)} \quad (6.7)$$

$$t_c \geq -\ t_{(1-\alpha'/2);\ (N-2)} \quad (6.8)$$

where α' is the significance level and t the cumulative t-Distribution factor for α' and (N-2) degrees of freedom. Table 6.14 present the results of these tests. These results show that the hypothesis of k=0 should be rejected at all significance levels. That is, the data used for the model development process, collected from the previously mentioned urbanizations in San Juan, Ponce and Mayaguez, reflects the fact that the water-use growth index (i.e. slope) differs significantly from zero at all confidence levels in these three cities under study. These results give credit to the assumed hypothesis that assessed property value (V) could be used to predict water-use, if an exponential approximation is used as the relating functional model.

6.8 Comparative Summary of Alternate Tests-of-Hypothesis for Model Parameters (F-test)

The above results were also checked by performing alternate (F) test-of-hypothesis. The new test statistic used was (Fisher's F)

$$F = \frac{\text{Mean Square Due to } k/\alpha_L}{\text{Residual Mean Square}}$$

whose critical rejection region is given by (cumulative F-Distribution)

$$F \geq F_{(1-\alpha'); (1, N-2)}$$

Table 6.15 depicts the results which ratify those previously obtained.

TABLE 6.14

Comparative Summary of Tests-of-Hypothesis for k (t-Test)

Water System Design Index	Equivalent Month	Significance Level α' (%)	San Juan 108 D.F.			Ponce 93 D.F.			Mayaguez 46 D.F.		
			t	t_c	Concl.	t	t_c	Concl.	t	t_c	Concl.
gpcd	AVEMO	20	5.258	1.290	S*	3.626	1.291	S	9.241	1.301	S
		10		1.661	S		1.662	S		1.680	S
		5		1.982	S		1.987	S		2.014	S
		1		2.625	S		2.632	S		2.690	S
	MAXMO	20	4.488	1.290	S	4.218	1.291	S	6.473	1.301	S
		10		1.661	S		1.662	S		1.680	S
		5		1.982	S		1.987	S		2.014	S
		1		2.625	S		2.632	S		2.690	S
gpd	AVEMO	20	5.713	1.290	S	3.303	1.291	S	5.110	1.301	S
		10		1.661	S		1.662	S		1.680	S
		5		1.982	S		1.987	S		2.014	
		1		2.625	S		2.632	S		2.690	S
	MAXMO	20	4.979	1.290	S	3.970	1.291	S	4.289	1.301	S
		10		1.661	S		1.662	S		1.680	S
		5		1.982	S		1.987	S		2.014	S
		1		2.625	S		2.632	S		2.690	S

*S = "Significant" Difference

TABLE 6.15

Comparative Summary of Alternate Tests for Model Parameter

k (F-Test)

Water System Design Index	Eqivalent Month	Significance Level α (%)	San Juan F	San Juan F_c	San Juan Concl.	Ponce F	Ponce F_c	Ponce Concl	Mayaguez F	Mayaguez F_c	Mayaguez Concl.
			1 and 108 D.F.			1 and 93 D.F.			1 and 46 D.F.		
gpcd	AVEMO	20	27.642	1.66	S	13.151	1.67	S	85.394	2.84	S
		10		2.76	S		2.77	S		4.08	S
		5		3.92	S		3.96	S		5.42	S
		1		6.85	S		6.96	S		8.83	S
	MAXMO	20	20.144	1.66	S	17.795	1.67	S	41.896	2.84	S
		10		2.76	S		2.77	S		4.08	S
		5		3.92	S		3.96	S		5.42	S
		1		6.85	S		6.96	S		8.83	S
gpd	AVEMO	20	32.638	1.66	S	10.910	1.67	S	26.113	2.84	S
		10		2.76	S		2.77	S		4.08	S
		5		3.92	S		3.96	S		5.42	S
		1		6.85	S		6.96	S		8.83	S
	MAXMO	20	24.787	1.66	S	15.759	1.67	S	18.391	2.84	S
		10		2.76	S		2.77	S		4.08	S
		5		3.92	S		3.96	S		5.42	S
		1		6.85	S		6.96	S		8.83	S

CHAPTER VII- GRAPHICAL COMPARISON OF WATER-USE MODELS FOR SAN JUAN, PONCE AND MAYAGUEZ

As a first step in the graphical comparison of the developed models for the three cities under study, they were plot the set of axes.

7.1 Apparent Slopes

The Observation of Figures 7.1 and 7.2 gives an idea of how close the slopes for some models are to one another, or if they are bounded to differ significantly. These are presented in semi-log graph paper so that all models plot as straight lines, and thus their inclinations are more easily compared. In all four comparisons the plots are of water use -vs- assessed property value (in $1,000'S). Those in Figure 7.1 present the models for gallons per capita daily in the equivalent months of average and maximum water use, and Figure 7.2 the models for gallons per day per dwelling unit in the same equivalent months.

7.2 Intercepts

In addition to checking the apparent slopes, the intercepts were also compared for possible significant differences between those of each two models (two at a time). This is necessary because the more comparison of slopes is not enough to ascertain true differences between the developed models. Two models might not differ in slope, but have a very significant difference in their intercepts. Again the observations were based on the appearance of Figures 7.1 and 7.2.

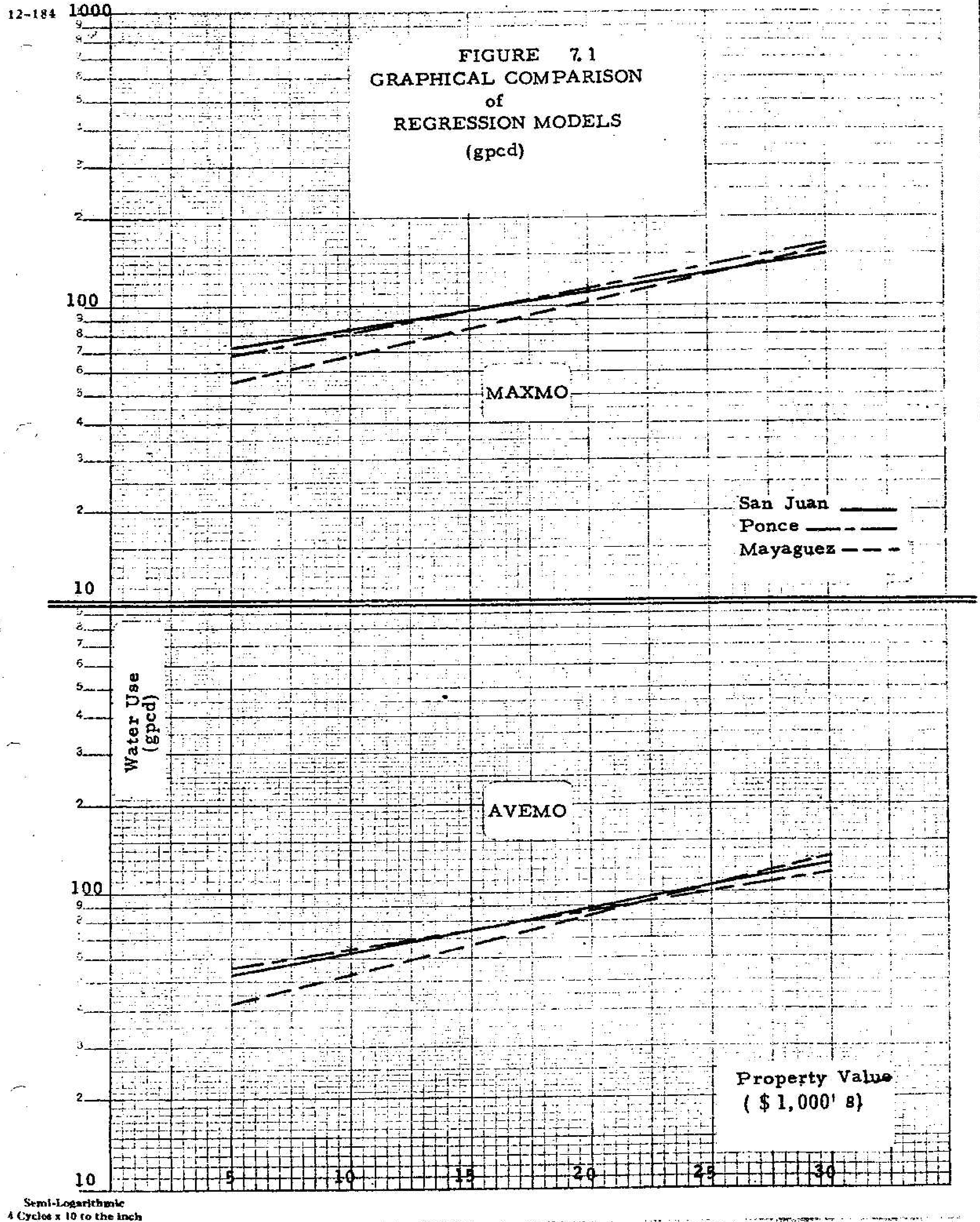
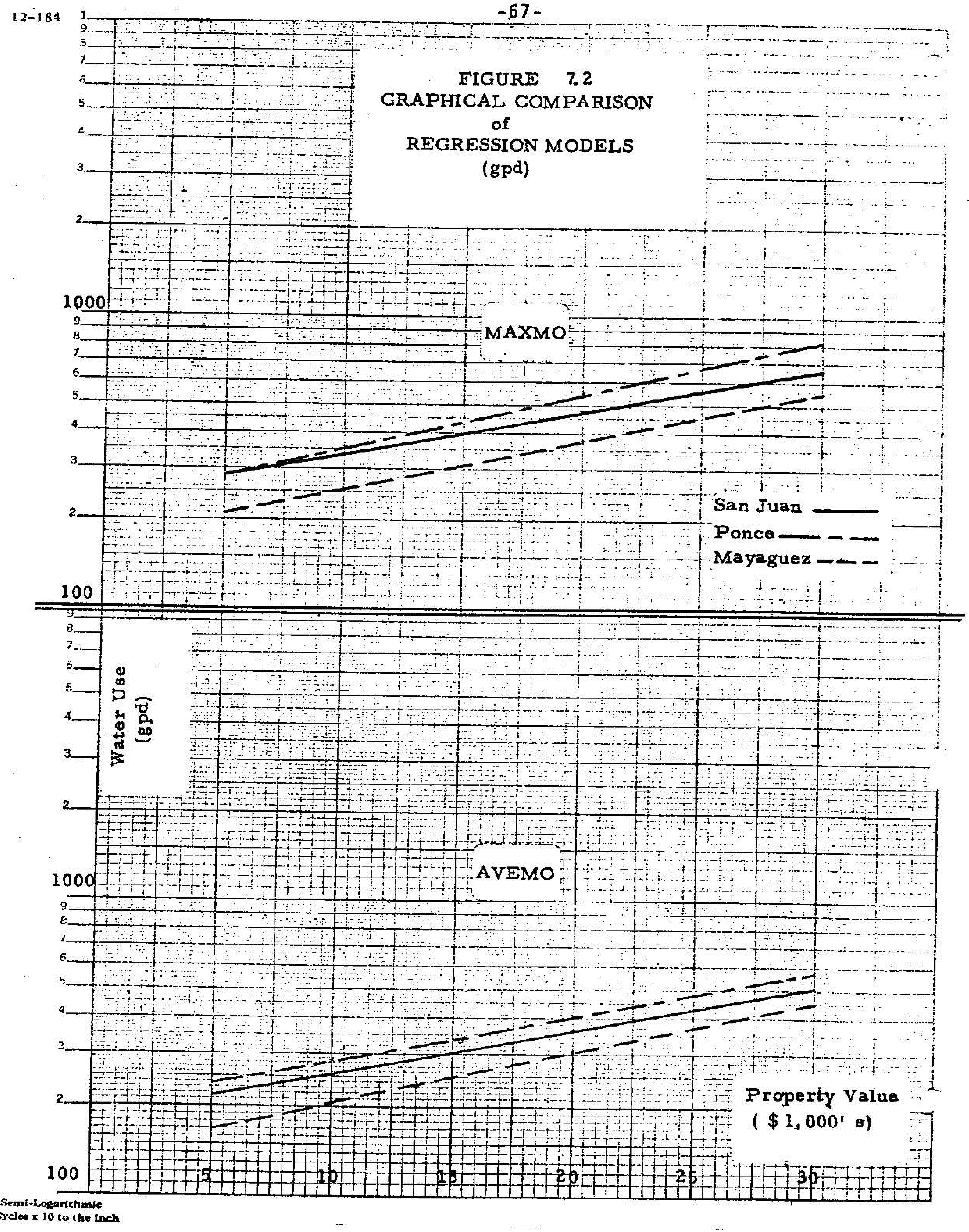


FIGURE 7.1
GRAPHICAL COMPARISON
of
REGRESSION MODELS
(gpcd)
MAXMO
AVEMO
San Juan
Ponce
Mayaguez
Water Use (gpcd)
Property Value ($ 1,000's)
12-184
1000
100
10
5
10
15
20
25
30
Semi-Logarithmic
4 Cycles x 10 to the inch

FIGURE 7.2
GRAPHICAL COMPARISON
of
REGRESSION MODELS
(gpd)



7.3 Some Comments on the Graphical Comparison

From the observation of Figure 7.1 it could be infered that the apparent slopes of the models corresponding to the cities of San Juan and Ponce do not seem to differ much, while the model for Mayaguez appears with a different inclination than that of the other two cities. This is true for the gallons per capita daily index in both the average and maximum months of equivalent water use. The model corresponding to Mayaguez seem to be "more inclined" (i.e. has a greater slope) than those of the other two cities. It is also observed that in the property value range of $20,000 to $30,000 these differences in per capita water use seem to lessen; no significant differences are either observed for the intercepts of the San Juan and Ponce models, while that of Mayaguez seems considerably lower in gpcd for both AVEMO and MAXMO.

The gallons per day index charted on Figure 7.2 for the equivalent month of average water use does not seem to reflect significant differences in slope for the three models. However, the intercepts, although not shown as different for San Juan and Ponce, again seem to differ (significantly lower) for the Mayaguez model. The MAXMO chart in Figure 7.2 does not depict differences between Ponce and Mayaguez. That for the San Juan model appears less inclined. Once more intercepts differ (graphically) for Mayaguez appearing considerable lower than those for San Juan and Ponce (which do not seem to differ) in both AVEMO and MAXMO.

The analyses of next chapter will deny or confirm these apparent differences between the developed water-use models for the cities of San Juan, Ponce and Mayaguez, Puerto Rico.

CHAPTER VIII- ANALYTICAL COMPARISON OF MODEL PARAMETERS

In addition to the forementioned graphical comparative observations and in an effort to confirm or deny them, analytical comparisons were also performed.

8.1 Comparative summary of the Results Obtained from the Tests Performed on Model Parameters to Search for Significant Differences

To ascertain or deny the observed apparent graphical differences, the corresponding model parameters were subject to test-of-significance. Parameters were tested two-at-a time for the cities of San Juan -vs- Ponce, San Juan -vs- Mayaguez and Ponce -vs- Mayaguez respectively.

Table 8.1 presents a summary of the results obtained from these comparisons.

8.1.1 San Juan -vs- Ponce Models

To compare the parameters k and α_L for the models of Ponce and San Juan, the tests performed were as follows:

TABLE 8.1

Comparative Summary of the Tests Performed

On Model Parameters to Search

For Significant Differences

(gpd in AVEMO)

Water System Design Index	Significance Level (%)	Ponce -vs- San Juan 93 D.F.			Mayaguez -vs- Ponce 46 D.F.			Mayaguez -vs- San Juan 46 D.F.		
		t	tc	Concl.	t	tc	Concl.	t	tc	Concl.
k	5	0.794	1.984	NS*	0.351	2.014	NS	1.270	2.014	NS
	1	0.794	2.628	NS	0.351	2.690	NS	1.270	2.690	NS
α_L	5	1.200	1.984	NS	5.300	1.984	S	5.600	1.982	S
	1	1.200	2.628	NS	5.300	2.628	S	5.600	2.625	S

*S= Significant; *NS= not significant

Hypotheses:

$H_1 : k_p = k_{SJ}$; (7.1)

$A_1 : k_p \neq k_{SJ}$ (7.2)

$H_2 : \alpha_{L_p} = \alpha_{L_{SJ}}$; (7.3)

$A_2 : \alpha_{L_p} \neq \alpha_{L_{SJ}}$ (7.4)

Test Statistics:

$$t_1 = (k_p - k_{SJ}) / \sqrt{VAR\ (k_p)} \qquad (7.5)$$

$$t_2 = (\alpha_{L_p} - \alpha_{L_{SJ}}) / \sqrt{VAR\ (\alpha_{L_p})} \qquad (7.6)$$

where k_p, α_{LP}, k_{SJ}, α_{LSJ} are the model parameters for Ponce and San Juan respectively, and

$$VAR\ (k_p) = S^2_{E_p} / \Sigma\ V^2_P \qquad (7.7)$$

$$VAR\ (\alpha_{L_p}) = S^2_{E_p}\ (1/N_p + \bar{V}^2_P / \Sigma\ V^2_P) \qquad (7.8)$$

in which

$S^2_{E_P}$ is the variance-of-errors of estimate for the Ponce sample data (appears as "VAR OF ERRORS OF ESTIMATE" in computer printout);

V_P is each individual datum for property value in Ponce;

$\bar{V}_P$ is the average property value for N_P dwellings in the Ponce sample of dwellings

Rejection Regions:

$$t_{1;2} \geq t_{(1 - \alpha'/2)}\ ;\ (N_P\text{-}2) \qquad (7.9$$

$$t_{1;2} \leq -\ t(1\text{-}\alpha'/2);\ (N_P\text{-}2) \qquad (7.10)$$

where α' is the significance level and t is the cumulative t-Distribution factor for α' and N_P-2 degrees of freedom.

8.1.2 San Juan -vs- Mayaguez Models

The procedure and tests followed to compare the model parameters for these two cities were the same as those in 8.1.1, except that in formulas 7.1 to 7.10 the subscripts in the component variables varied accordingly.

8.1.3 Ponce -vs- Mayaguez Models

As in the case of the San Juan -vs- Mayaguez models, all tests conducted were the same as in 8.1.1, except that the corresponding subscripts were changed to correctly identify the cities under comparison.

8.2 Some Comments on the Results of the Analytical Comparisons of Model Parameters

Again these analytical comparisons ratify the graphical observations previously made in Section 5.1. As before no significant differences were determined by testing San Juan and Ponce models while a very significant difference was noted in comparing the models for San Juan -vs- Mayaguez and Ponce -vs- Mayaguez respectively.

In comparing slopes and intercepts in the Ponce and Mayaguez models, for the per dwelling daily water use in the equivalent month of average usage, it was noted that although they did not differ in slope, there was a significant difference in model intercepts. This result points towards a higher daily dwelling water consumption in the city of Ponce, P.R. as compared to Mayaguez, in the same property value brocket.

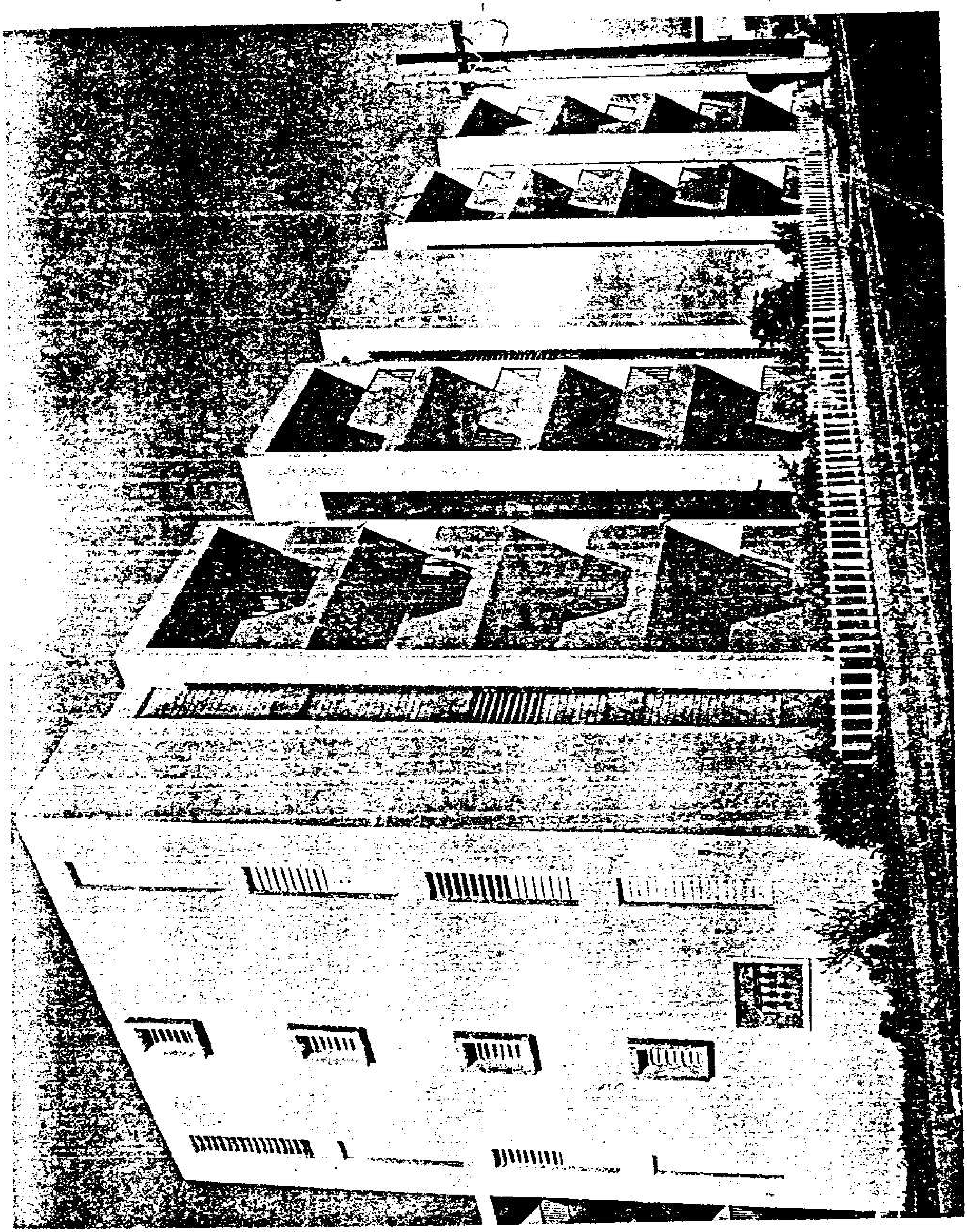


Figure 9.2
Typical Public Urbanization
Dwelling

CHAPTER IX- PUBLIC DWELLINGS ANALYSES

All the forementioned analyses, conducted for the private urbanization dwellings data, were also performed on the public dwellings data. The main difference was that the property value factor was not used for prediction purposes. Since the families using these dwellings are allocated mainly on the basis of the family size and not its income, the property value of the dwelling does not reflect adequately their income status. (See Figure 9.2)

The number of bedrooms is a more adequate means of explaining and predicting water use in these dwellings. However, since the number of bedrooms in a dwelling unit is an important factor in the determination of property value, and this value is well correlated with some factors which influence water use (13), the number of bedrooms serves well a a practical indirect indicator of this relationship.

The data used in the analysis of this type of dwellings was obtained mainly from the canvassing of the following public urbanization areas:

In San Juan, Puerto Rico:

Alhambra

Guaynabo

José C. Barbosa

Juana Matos

Los Alámos

Nemesio Canales

Rafael Torrech

Rosaleda

Villa España

Virgilio Dávila

Vista Hermosa

In Ponce, Puerto Rico:

Arístides Chavier

Dr. Gándara

Dr. Pila

La Ceiba

López Nusa

Villa Pámpanos

In Mayaguez, Puerto Rico:

Alemañy

Cuesta Las Piedras

Eleonor Roosevelt

Franklin Delano Roosevelt

John F. Kennedy

Marini

Sábalos

In subjecting the collected data to analyses, no significant differences were observed for the three cities. Only the gallons per day per dwelling unit index (gpd) resulted relevant for estimation purposes (13).

The water use estimation model in this case is the same as that of formula 5.1 with the exception that the assessed property value V is replaced by the number of bedrooms per dwelling unit R.

Table 9.1 presents a comparative summary of the corresponding model parameters for San Juan, Ponce and Mayaguez and Tables 9.2 to 9.5 their confidence limits.

Figure 9.1 compares, graphically, the three developed models and Table 9.6 summarizes some characteristics of the samples under consideration.

The material of next chapter was basically covered in the previous publication for the Mayaguez area and is included here, with some minor modifications, for the sake of completion.

TABLE 9.1

Comparative Summary of Model Parameter Values

Public Dwellings

Water System Design Index	Equivalent Month	Parameters					
		LNA (α_L)			LNB (k)		
		San Juan	Ponce	Mayaguez	San Juan	Ponce	Mayaguez
gpd	AVEMO	4,552	4.243	4.159	0.269	0.306	0.349
	MAXMO	4.893	4.563	4.535	0.236	0.255	0.288

TABLE 9.2

Comparative Summary of Confidence Limits for Model Parameters in Public Dwellings 80% Confidence Level

Water System Design Index	Equivalent Month	Limit	For α_L			For k		
			San Juan D.F. t=1.294	Ponce D.F. t=1.301	Mayaguez D.F. t=1.294	San Juan D.F. t=1.294	Ponce D.F. t=1.301	Mayaguez D.F. t=1.294
gpd	AVEMO	Upper	4.736	4.377	4.343	0.338	0.368	0.430
		Lower	4.367	4.109	3.976	0.201	0.245	0.268
	MAXMO	Upper	5.098	4.747	4.723	0.312	0.340	0.371
		Lower	4.688	4.379	4.348	0.160	0.171	0.205

TABLE 9.3

Comparative Summary of Confidence Limits for Model

Parameters in Public Dwellings 90% Confidence Level

Water System Design Index	Eqivalent Month	Limit	For α_L			For k		
			San Juan D.F. t=1.667	Ponce D.F. t=1.680	Mayaguez D.F. t=1.666	San Juan D.F. t=1.667	Ponce D.F. t=1.680	Mayaguez D.F. t=1.666
gpd	AVEMO	Upper	4.789	4.166	4.395	0.358	0.386	0.454
		Lower	4.314	4.070	3.923	0.180	0.227	0.244
	MAXMO	Upper	5.157	4.800	4.776	0.312	0.364	0.395
		Lower	4.629	4.326	4.294	0.160	0.146	0.181

TABLE 9.4

Comparative Summary of Confidence Limits for Model Parameters in Public Dwellings 95% Confidence Level

Water System Design Index	Equivalent Month	Limit	For α_L			For k		
			San Juan D.F. t=1.994	Ponce D.F. t=2.014	Mayaguez D.F. t=1.992	San Juan D.F. t=1.994	Ponce D.F. t=2.014	Mayaguez D.F. t=1.992
gpd	AVEMO	Upper	4.836	4.451	4.441	0.375	0.402	0.474
		Lower	4.267	4.035	3.877	0.164	0.211	0.224
	MAXMO	Upper	5.208	4.848	4.824	0.354	0.386	0.416
		Lower	4.578	4.279	4.247	0.119	0.125	0.160

TABLE 9.5

Comparative Summary of Confidence Limits for Model Parameters in Public Dwellings 99% Confidence Level

Water System Design Index	Equivalent Month	Limit	For α_L			For k		
			San Juan D.F. t=2.648	Ponce D.F. t=2.690	Mayaguez D.F. t=2.643	San Juan D.F. t=2.648	Ponce D.F. t=2.690	Mayaguez D.F. t=2.643
gpd	AVEMO	Upper	4.930	4.521	4.534	0.410	0.434	0.515
		Lower	4.174	3.965	3.785	0.129	0.179	0.183
	MAXMO	Upper	5.312	4.943	4.918	0.392	0.430	0.458
		Lower	4.474	4.183	4.152	0.080	0.081	0.118

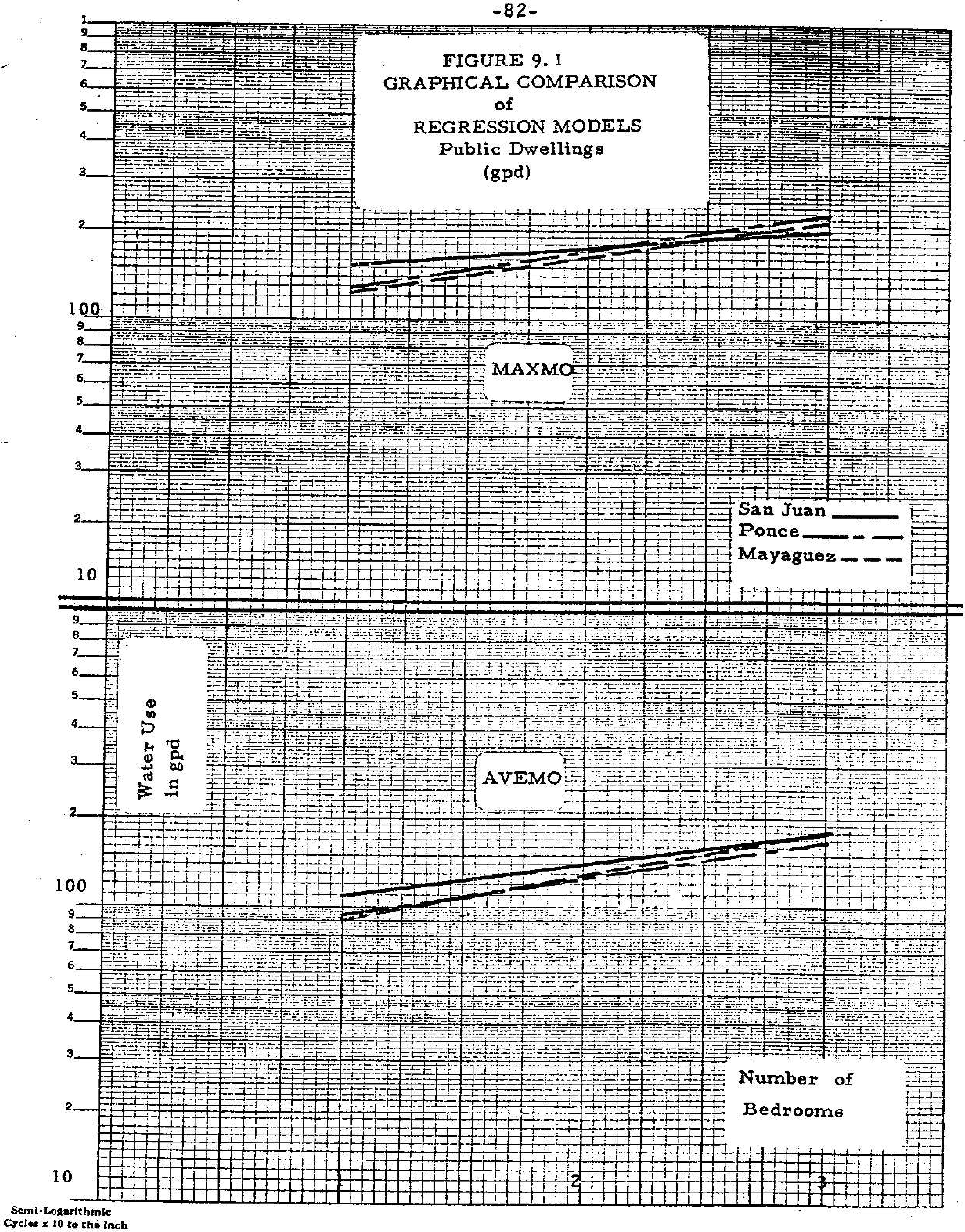


FIGURE 9.1
GRAPHICAL COMPARISON
of
REGRESSION MODELS
Public Dwellings
(gpd)
MAXMO
AVEMO
San Juan
Ponce
Mayaguez
Water Use
in gpd
Number of
Bedrooms
100
10
1
2
3
Semi-Logarithmic
1 Cycles x 10 to the Inch

TABLE 9.6

Some Characteristics of the Sample of Public Dwelling Units Under Study

Dwelling Characteristic	San Juan			Ponce			Mayaguez		
	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.
Number of Bedrooms Per dwelling	1	2.5	4	1	2.0	3	1	2.2	3
Gallons Per Day Per Dwelling Unit Used in AVEMO	65	180	414	55	133	278	48	140	292
Gallons Per Day Per Dwelling Unit Used in MAXMO	78	240	610	70	160	353	52	180	340

CHAPTER X- MODEL USES AND LIMITATIONS

The developed model are intended mainly to explain the form of the relationship between water use and some main dwelling characteristics, and to serve as a residential water-use predictor (estimator).

10.1 Using the Generated Model (s) as a Predictive Tool.

When used as predictors, the developed models are not recommended for individual-residence water-use estimation. They are recommended for use with groups of relatively homogeneous residences (in nature and type) as classified in this study. (See section 2.4) Water-use estimation would be for average magnitudes of water use in AVEMO and MAXMO.

In order to be able to make these estimates say, for a new housing development which is being planned, advanced estimates (data) on the average assessed property value (average number of bedrooms for the case of public dwellings) for groups of relatively homogeneous dwellings are required (Section 10.2).

10.2 A-Suggested Procedure for the Estimation of Water Usage with the Developed Model (s) in Private Urbanization Dwellings

The water-use estimates for urbanization dwelling developments are suggested to be done as follows[1]:

1. Arrange data from all the dwellings proposed for the housing development, in relatively homogeneous

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1. The user could also find other ways to do the estimates.

groups. Each group should be composed of dwellings which are similar in nature and type (Section 2.4), and the group assessed property value range should not be wider than \$5,000.00 (e.g. \$15,000.00 to \$20,000.00; \$20,000.00 to \$25,000.00; etc.).

2. With the data of step 1, compute the average assessed property value (in dollars) of each of the homogeneous groups and divide this value by 1,000.
3. Using the final property value obtained in step 2, and employing Equation 6.1, compute the corresponding average water-use value (in natural log form, $\hat{W}_{LE}$).
4. Convert (find the antilogarithm of $\hat{W}_{LE}$) the results of sept 3 to obtain the water-use values in gallons per day per dwelling unit (gpd) and gallons per capita daily (gpcd) for equivalent months of average and maximum water use (AVEMO and MAXMO) for each homogeneous groups of dwellings.
5. Multiply the value on the estimated number of gallons per day per dwelling unit (gpd) obtained in step 4 for each group, by the number of dwellings in the group (group size). This will give estimates of the total amount of water usage to be expected (in the average) for each group of homogeneous dwellings. This should be done for both AVEMO and MAXMO.
6. Add the results of step 5 for all groups. This will

give estimates (for AVEMO and MAXMO) of the total average amount of water usage to be expected for the whole housing development.

7. If confidence limits are desired for the results of step 4 in each group of homogeneous dwellings, the following equation is recommended:

$$\left.\begin{matrix} U.C.L.\hat{W}_{L_E} \\ L.C.L.\hat{W}_{L_E} \end{matrix}\right\rangle W_{L_E} \pm t_{(1+\gamma')/2\ (N-2)} \sqrt{VAR\ (\hat{W}_{L_E})} \qquad (10.1)$$

where

$$VAR\ (\hat{W}_{L_E}) = S_E^2\ \ 1/N + (V - \bar{V})^2\ / \Sigma V^2 \qquad (10.2)$$

and V is the dwelling characteristic used as factor for estimation purposes. $\hat{W}_{L_E}$ is the estimate obtained in step 3 for each group of dwellings, computed at a point where V is equal to $\bar{V}$; t is the Students'-t factor for a γ' confidence level and (N-2) degrees of freedom; N is the number of dwellings in each homogeneous group; and S_E^2 is the variance of errors-of-estimate for the model predictor whose values could be obtained from Table 6.9. Making the estimate $\hat{W}_{L_E}$ at a point where V equals $\bar{V}$, will result in reducing Equation 10.2 to

$$VAR\ (\hat{W}_{L_E}) = S_E^2/N \qquad (10.3)$$

8. Convert (find the antilogarithm) the results of Equation 10.1 on both limits in each group of

dwellings for gpd in AVEMO and MAXMO.

9. Multiply the values of step 8 in each group by the group size. This will give an estimate of the expected upper and lower bounds for the average magnitudes of water use in each group, for AVEMO and MAXMO.

10. Add the results of step 8 (separately for upper and lower limits for all groups. This will give estimates (for AVEMO AND MAXMO) of the lower and upper bounds for the average amounts of water usage to be expected for the whole urbanization development.

B-Suggested Procedure for Water-Use Estimation in Public Dwellings

A procedure which is similar to that suggested for urbanization dwellings applies for the case of public dwellings with the following changes:

a- The grouping of step 1 should be done on the basis of the number of bedrooms. This grouping would bring together in each group, the data of these dwellings which are planned to have a single bedroom, another group would be composed of data from two-bedroom dwellings, and so forth.

b- In step 2 the average number of bedrooms should be computed, and no division by 1,000 is required.

c- Equation 6.1 should be used in step 3 with the planned number of bedrooms (R) replacing the general prediction factor (V).

d- Steps 4,5 and 6 should be done in the same way.

e- In step 7, the characteristic (V) is replaced by (R) in Equation 10.2.

f- Steps 8,9 and 10 are done in a similar manner.

10.3 A Word of Caution

Finally, since many statistical populations are relatively dynamic (exhibit some tendency to change), it is recommended to whoever uses this model that periodic checks (e.q. every 5 to 8 years) be conducted to determine whether model parameter values (α_L and k) still hold appropriate. In doing these checks a procedure similar to that followed in Chapter VI of this study is suggested. Reference 13 contains a listing of a computer program that could be employed in the conduction of these checks.

CHAPTER XI- CONCLUSION

The results of this study have shown the feasibility of estimating water-use in residential developments of the private type (13), based on property value as the basic characteristic. The rationale employed was that property assessed value serves well as an indirect pratical indicator of the effect on water use of such socioeconomic factors as number and kind of home water-using fixtures, lawn and garden areas, automobile washing requirements, education, habits, ocupation, and effective family buying income.

Significant differences were observed in comparing private urbanization models for the cities of Ponce and Mayaguez and San Juan and Mayaguez respectively. It is therefore recommended that separate models be employed for estimation purposes in these cities, using the formulas and procedures explained in Section 10.2 A.

No significant differences were noted for the generated models of the three cities in the public dwellings areas. Thus, a single model is recommended for water-use estimation purposes in these areas. Section 10.2 B contains a suggested procedure to be followed in achieving this objective.

APPENDIX I- <u>REFERENCES</u>

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APPENDIX II- BRIEF EXPLANATION OF SOME ABBREVIATIONS CONTAINED IN EXHIBITS 6.1 AND 6.2

KSELEC- - an indicator of the water-use index for a given month of water usage, that is being used for model -development purposes. For example KSELEC = 5 refers to the employment of the number of gallons per capita daily of water usage in an equivalent month of average use.

MINMO - equivalent, month of minimum water usage.

AVEMO - equivalent month of average water usage.

MAXMO - equivalent month of maximum water usage.

W - estimated equivalent monthly water use, when obtained from the developed model.

V - property assessed value. Includes both the house and its lot.

A,B - main model parameters.

LNA, LNB - the natural logarithms of the evaluated model parameters.

LNW - the natural logarithm of the observed water-use value.

LNWH - the natural log. of the estimated water use value (from water-use model)

DLNWH - the difference between the observed and estimated natural logs. of water-use values.

DLWH2 - the square of DLNWH.

SDLWH - the sum of all DLNWH values (algebraic sum).

SDLWH2 - the sum of all DLWH2 values.

TPRDF - t-distribution percent confidence levels (80, 90, 95 and 99% respectively).

T, F - test-of-hypotheses parameters for comparison with Student's -t and Fisher's-F distribution critical values respectively.