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Tampere University of Technology
Department of Civil Engineering
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Postgraduate Course in Water Supply and Sanitation

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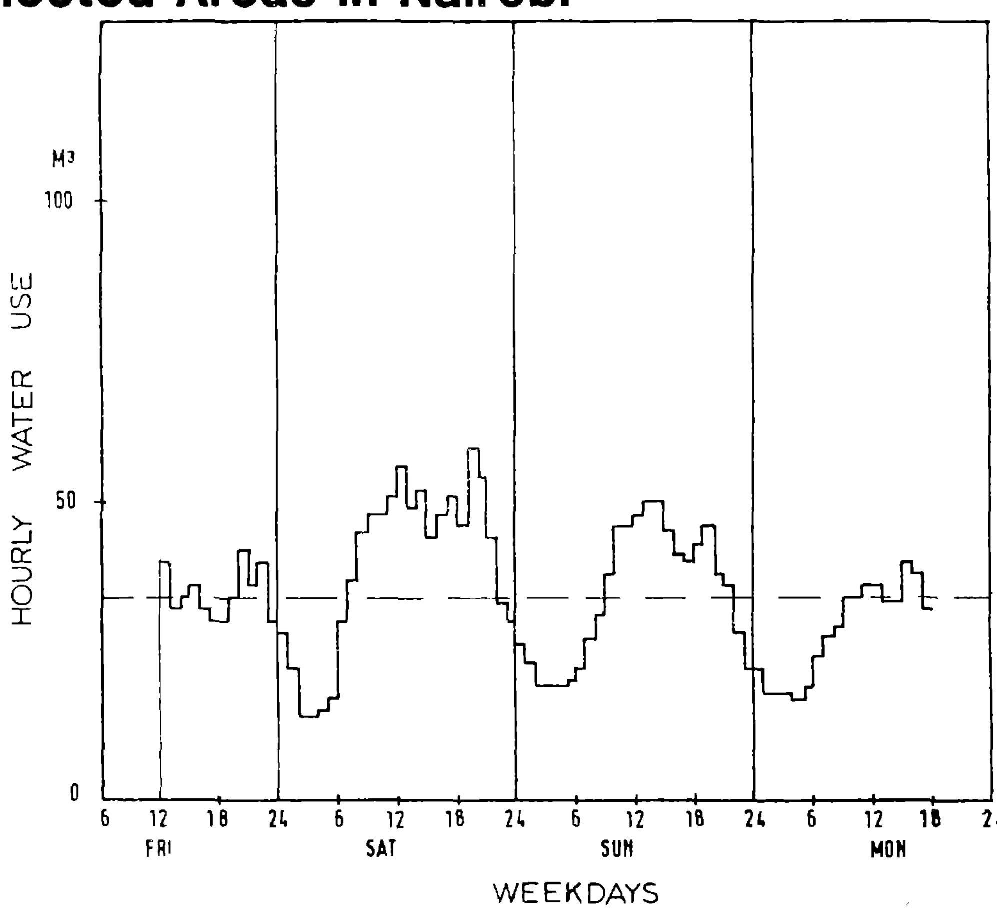
Domestic Water Consumption Patterns in Selected Areas in Nairobi



Tampere 1986

DOMESTIC WATER CONSUMPTION PATTERNS IN SELECTED AREAS IN NAIROBI

by

NGARI, SAMUEL

Thesis submitted to the department of civil engineering, Tampere University of Technology in partial fulfilment of the requirements for the degree of Master of Science in Engineering

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DOMESTIC WATER CONSUMPTION PATTERNS IN SELECTED AREAS IN NAIROBI

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ABSTRACT

Domestic water consumption has formed about 50 % of the total water supply in Nairobi for the last 10 years. Nairobi City Commission (NCC), which is responsible for the water supply in the city, has rightly classified domestic demand rates following the income groups which also correspond to different housing types.

This study examines the per capita water consumption and variation in domestic water usage in Nairobi West, Madaraka and Kahawa West housing estates.

A total of 2600 meters which is 3 % of all water connections in Nairobi was read. A questionnaire survey was conducted for the purposes of population estimate for each area. Master meters were located at the entry to each study area which had been isolated from the neighbouring distribution networks. Domestic water consumption figures from the billing records of the NCC were also examined.

The results from this study showed that the trend in per capita water consumption is consistent with the classification chosen. The medium income per capita figure of 115 l/cap/day compared favourably with 136 l/cap/day from the design file and 115 l/cap/day from other studies of similar areas. The chosen high income area was conclusively not representative with 120 l/cap/day compared with 270 l/cap/day used in design in similar areas. The peak factors also showed the expected trend according the location classification.

Although these figures obtained from this study are not adequate for design or prognosis, they are nevertheless useful in conjunction with other results which could be investigated for other similar areas.

1 INTRODUCTION

Interest has continued in the question of water use internationally. Investigations have been done and are going on especially into domestic water usage designed to provide basic information about household water use in order to improve the demand forecasting.

Estimates of per capita use of water for domestic purposes can be seen to be of three types:

1) dividing the total withdrawal of water with the number of people believed to be served;
2) institutions - educational, military, penal, welfare etc. - which, however, are so regimented that they have little use in predicting except in similar institutions;
3) studies made of sample households where the number of inhabitants is counted, patterns of use and factors affecting the use are studied.

It is the third method of estimation that this study is addressed to. The study is aimed at determination of water use patterns and demand rates in selected residential areas of Nairobi. The results are intended to be compared to previous reports, handbooks and design criteria.

It has been the tradition of the Water and Sewerage Department of the Nairobi City Commission to classify domestic user categories according to high, medium and low income groups of people. The chosen areas fall fairly into these groups. Furthermore, the water distribution arrangement makes the isolation of the areas proceed without a serious interruption of the normal water supply.

Attention is also drawn to the need for water conservation. The water conservation practices are of two classes: consumer oriented and utility oriented consisting principally of the leakage control. This study has been connected in part with an on-going leakage survey by a consultant. The results of the survey are also useful when estimating the domestic total consumption which forms about 55 % of the total water consumption in Nairobi.

The need for reliable statistics from accurate field data is a continuing requirement for management of a water undertaking. Not only do they help in making accurate forecasts but also raise the consumer's confidence in the undertaking by charging him for water he has actually consumed.

No attempt has been made to study the other user categories, in spite of their combined effect on the total water consumption, due to the size of the work and the time involved. But this would be a continuation of such a report as this.

2 WATER DEMAND IN NAIROBI

2.1 Definition of water requirements, water demand and water consumption

The terms "water requirements" and "water demand" are frequently used interchangeably. In the language of economics, however, these words have special meanings. "Demand" refers to the amount of water that would be consumed if the water was free of charge and available in unlimited quantities. "Consumption" is the actual amount of water consumed. "Requirement" is actually the demand without the consideration of price. Whether the price of water increases or not the requirement would be the same. Generally demand is higher than consumption. Changes in policy (e.g. changes in price, modifications of tariff structure etc.) can cause discontinuities of the trend of consumption which do not necessarily go together with a change in demand (Hanke and Boland 1971).

2.2 Capacity of the Nairobi Water Supply System

The urban area of Nairobi is served by a piped water distribution system supplying conventionally treated water from three major and one minor source. These are:

1) Ngethu treatment works for both Chania I and II supply schemes,
2) Sasumua reservoir and treatment works,
3) Ruiru dam,
4) Kikuyu springs (minor source).

The normal maximum supply rate is currently standing at 217 200 m^3/day. In addition some areas such as Karen-Langata and parts of the eastern extension are supplied by water from boreholes. This amounts to about 4 800 to 5 500 m^3/day. Some industries supplement water supply from mains by about 3 500 to 3 700 m^3/day from their own boreholes.

2.3 Water consumption by user categories

The total water consumed in Nairobi is divided into the following categories: domestic, commercial, industrial and public. To these is added "unaccounted for" water which represents the shortfall between the total sold and the total water produced. The total water demand projected in 1979 is as shown in table 1.

Table 1. Intermediate projection of average annual water demand on daily basis (Howard Humphreys 1985).

Year	Total demand (m^3/day)
1979	137 982
1985	200 117
1990	278 132
1995	390 125

The distribution of this water to the mentioned categories is shown in table 2.

Table 2. Water consumption by user categories in 1967, 1975 and 1984. Percentage of total supply (Nairobi City Council 1977).

Category	1967	1975	1984
Industrial	8,6	9,7	10,0
Commercial	14,7	14,8	15,5
Public: Government Nairobi City Commission	9,9	8,7	8,7
Domestic	51,1	50,0	52,0
Unaccounted-for	15,7	16,8	16,8
Total	100,0	100,0	100,0

Domestic water consumption comprises about half of the total water requirements of the city, as can be deduced from the foregoing table.

Commercial water consumption is the water used in shops, private offices, restaurants, hotels etc. Currently it accounts for 15 - 16 % of the total consumption but it is growing at 4 % per year (Howard Humphreys 1985).

Industrial water consumption is almost exclusively confined to the designated industrial areas within the city boundary. Specific consumption rates in m^3/ha/day vary from area to area depending on present consumption, type of industry and development potential.

Public establishments category of water includes those establishments controlled by the Central Government and Nairobi City Commission (NCC) e.g. ministries, hospitals, colleges, schools, Nairobi University, Police and military institutions.

Unaccounted-for water could be as high as 40 % of the total production but it is expected to be reduced to 25 % by instituting conservation measures such as control of leakage (Howard Humphreys 1985). The billing cycle of the Water and Sewerage Department is able to categorise these uses and the historic trends can be thus obtained. These billing records provide the only source of information but eyebrows have been raised as to the accuracy of the results. In order to improve the demand projections investigations should be done especially on the domestic consumption category as it is the major water user. Subsequently it will be dealt with more at length.

2.4 Domestic water consumption

This is the quantity of water used in or around the house. Sometimes it is known as residential water consumption. Thus domestic water can be divided into household use, lawn or garden sprinkling and car washing. Figure 1 elaborates this further.

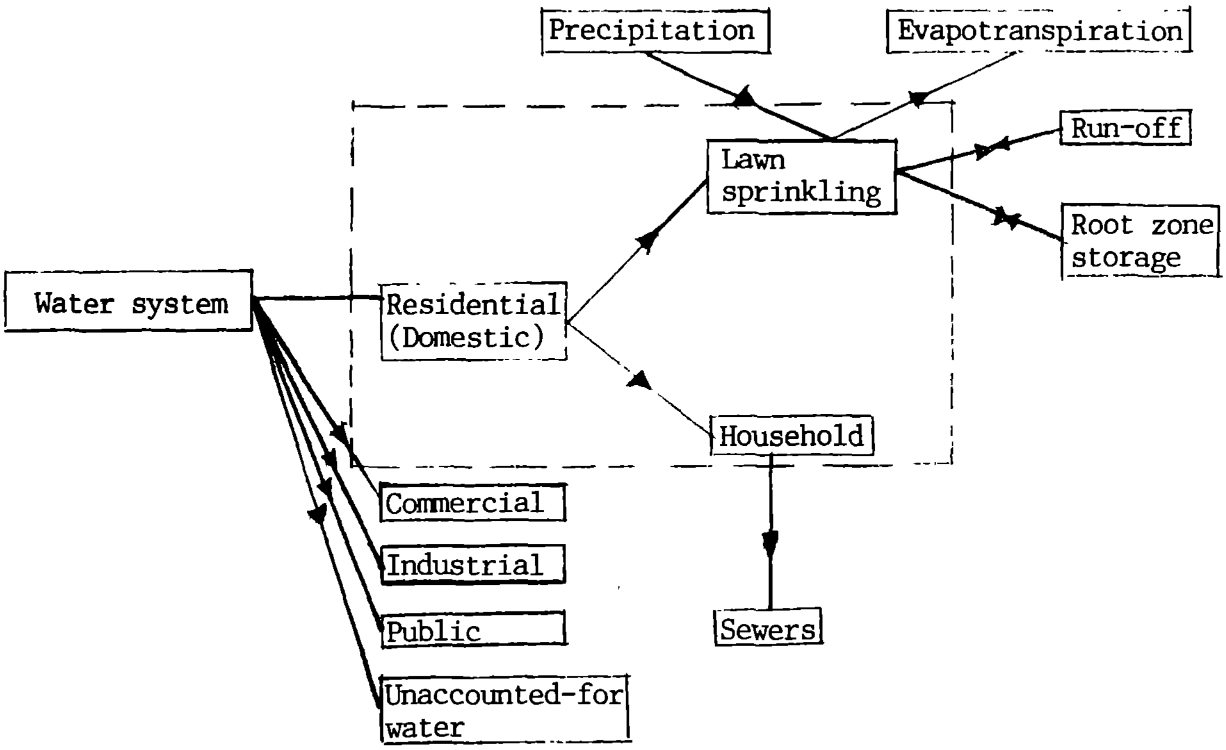

Figure 1. Schematic diagram of residential water use (Linaweaver et al 1967).

For planning purposes and for demand projections, domestic water was previously grouped according to how it was used by high, medium and low income groups of people in Nairobi. More recently, however, the consultants for the NCC's Water and Sewerage Department have recognised four types of residential categories (Howard Humphreys):

Type I — Substantially detached houses and modern houses with medium to large gardens. Full internal plumbing with high water consumption for normal domestic purposes plus additional amount for garden watering and car washing.

Type II — Housing estates with flats occupied in the middle income bracket. Full internal plumbing and use of water for car washing but generally little for garden watering.

Type III Majority of the population in the low income category living in small houses and flats in the older parts of the city and in the new site and service areas. Partially plumbed, often with a yard tap and one or two internal taps. Others are served by communal water points. Houses may or may not have flushing toilets.

Type IV Very low income housing and unauthorised shanty areas. Almost entirely dependent on licenced kiosks or wells.

Types I to III generally have metered supply with only those estates owned by Nairobi City Commission having no meters.

2.5 Characteristics of domestic water use

Domestic consumption is determined by a group of consumers which is large in number and where the water consumption of one individual consumer has no influence on the total consumption. It can be subdivided only in quite a low number of different uses (Knoppert 1976).

These uses may vary from the very basic ones such as cooking and washing only, in the modest households, to lawn sprinkling in the more posh households. The domestic use has a time and seasonal aspect in its variation. Domestic water consumption data is subject to a great number of influences. Improvement to such data is aimed at analysis and prediction of the development of separate influencing factors. These factors actually have a development pattern which is related to time. Thus water consumption is a function of such factors as population, number of dwellings, water consumption habits, economic productivity and price of water.

2.6 Trends in domestic water consumption in Nairobi

The records of the Water and Sewerage Department of Nairobi City Commission (NCC) provide the only readily available information on the trends of the water consumption and its distribution by consumer categories. However, as will be seen later, the accuracy and reliability are questionable.

Table 3. Trends of billed water consumption by consumer categories (Howard Humphreys 1985).

Category	Water consumption in 1000 m³/day		
	1975	1981	1984
Domestic	49,6	65,4	70,7
Commercial	13,9	17,7	17,7
Industrial	9,1	10,5	9,0
Public: Government	8,2	13,3	11,8
Nairobi City Commission	-	3,8	2,3
Total	78,1	110,7	111,8

Per capita consumption was estimated using the billed amount and the estimated number of persons served by the city water system. The population served has varied from 85 % of the total in 1975 to 90 % currently. These people are served from the mains through direct house connections, communal watering points and kiosks in the shanty areas.

Table 4. Population and domestic water consumption from the mains supply for the whole Nairobi (Howard Humphreys 1985).

Year	Population in 1000 persons		Billed water consumption in 1000 m³/d		Per capita consumption l/capita/d	
	Total	Served	Total	Domestic	Total	Domestic
1975	733	604	78,1	49,6	129	82
1981	945	841	110,7	65,4	132	78
1982	995	885	108,3	66,0	122	75
1983	1048	933	116,8	73,2	125	78
1984	1104	983	111,5	70,7	113	72

These figures indicate a general rise of the domestic water needs but a decline in per capita consumption. This downward trend has been attributed to supply contraints. The figure was expected to rise when Chania II water supply to Nairobi was commissioned in 1984. One of the scopes of this study was to estimate domestic per capita water consumption.

Table 5. Domestic water consumption projections (Howard Humphreys and Sons 1985).

Year	Domestic water requirement in 1000 m^3/day	Per capita consumption in l/capita/day
1985	81,1	79
1995	167,5	90
2010	377,3	103

Table 3 shows that the domestic water needs constitute a large share of the water requirements in the city. A slight adjustment of the domestic water consumption figure would yield a fair estimate of the water needs. Hence it is important to improve methods used to measure the domestic water in order to achieve better water demand projections for the city.

3 SURVEY OF DOMESTIC WATER CONSUMPTION

3.1 Choice and description of study areas

Three residential areas in Nairobi were chosen in consideration of the following advantages:
- ease of isolating the area without affecting the normal water supply,
- updated distribution plans available,
- reasonably good distribution pressure (a pressure recorder placed at one consumer's metering point was used to monitor the pressure variation during the study period).

These three areas were Nairobi West, Madaraka and Kahawa West Estates. Their locations and water supply distribution networks are shown in appendices 1 - 4. The areas fall into the first two of the four residential categories described earlier.

Nairobi West Estate contains substantially detached houses and modern houses with small to medium gardens. Full internal plumbing with high domestic water consumption exists. Car washing and garden watering are common in the estate. Madaraka and Kahawa Estates are housing estates with flats occupied by those in the middle income bracket. Full internal plumbing and use of water for car washing exist but generally no garden watering.

3.2 Collection of data

Data collection entailed a questionnaire distribution, measurements made in the chosen areas and a scrutiny of billing records from the Commercial Section of the Water and Sewerage Department of the Nairobi City Commission. The field operations followed closely the procedure of the leak detection survey.

3.2.1 Checking the operation of equipment

All valves, hydrants and meters were uncovered and checked for correct operation. Faulty consumer or bulk meters can be a source of error.

3.2.2 Installation of bulk meter

Distribution plans were examined for a suitable position for the bulk meter, through which the whole of the chosen area could be supplied. A 150 mm propeller meter was installed as shown in figure 2.

Figure 2. Master meter in the main leading to Nairobi West Estate.

3.2.3 Isolation of the study areas

The chosen areas were isolated from the rest of the city's distribution network. This was achieved by shutting off various valves after a careful study of the distribution plans for the area in question. The result of this operation ensured that the water entering the estate was either consumed there or lost through leakage. No water passed on to neighbouring areas. Pressure distribution in Nairobi West Estate during the study period is shown in appendix 5.

3.2.4 Data produced by metering

The kind of data sought by this exercise is the amount of water used by the consumers and its variations. The bulk meter measured the amount of water going to an estate in one week. The consumers' meters were read once in the beginning and after a week to obtain the amount used. Manual hourly inspection of the bulk meter produced hourly consumption in Nairobi West. A flow recorder was originally fixed to the bulk meter at Madaraka Estate as shown in figure 3. However, the result was inconclusive and the operation was replaced by manual inspection.

Figure 3. Automatic flow recorder.

3.2.5 Household data

Household data was obtained by distributing questionnaires to the consumers within the study areas at random. The intention was to obtain the number of consumers per household and data about household characteristics and their effect on the household consumption. The questionnaire used for the study is shown in appendix 7.

3.2.6 Period of survey

The field measurements were made for one week in October 1985 which was relatively dry. Hourly and daily readings of the bulk meter were made for one week but the consumer meters were only read at the start and end of the week. The questionnaire was distributed in November.

3.3 Analysis of data collected

In order to establish the present household consumption pattern, the field meter readings, the office billing records and the household information were thoroughly studied.

3.3.1 Area and population served

Madaraka Estate was built in 1972 and it comprises of 46 block of flats with a total of 680 flats. There are also shops, a restaurant, a hotel and a primary school. From the questionnaire survey the average occupancy was 5,1 bringing the total population to about 3500. During the survey 650 consumer water meters were read.

Nairobi West Estate comprises of 542 housing units. These consist of attached maisonettes, detached blocks of flats, shops, schools and a filling station. From the questionnaire survey, the average occupancy was 7,0. The population of the area is estimated to be 7500. During the survey 1491 consumer water meters were read.

Kahawa West consists of 500 houses plus shops and was constructed in 1980. The average occupancy is 4,0 bringing the population to about 2000. During the survey 463 consumer water meters were read.

3.3.2 Water consumption results

The results obtained by the exercise included the hourly and daily water consumption for the whole area of study, produced by the bulk meter results. These results were used to plot the variations of water consumption as shown later in figures 8 to 12. Also obtained are the individual household weekly water consumptions. The billed domestic water amounts from the Water and Sewerage Department (N.C.C.), although viewed with some sceptism, were analysed for monthly variation for years 1984 and 1985 for the whole of Nairobi.

4 ESTIMATING PER CAPITA DOMESTIC WATER CONSUMPTION

4.1 Components of domestic water usage

Water used in households can be divided into "person related" and "dwelling related" consumption. Person related consumption includes water used for drinking, toilet flushing and water used for hygiene (bathing or showering). Dwelling related consumption includes water for laundry, dishwashing, cooking, gardening and car washing. The domestic usage can also be classified into minimum consumption considered during shortages and in standpipe supplies and the high per capita consumption associated with piped supplies.

4.1.1 Minimum consumption

The minimum water consumption is difficult to determine since it varies with climate and prevailing social conditions. It embraces all basic uses for survival and is usually considered during shortages (if supply is to be restricted) or where supplies are taken from standpipes, tankers or handpumps. An example of estimated actual consumption obtained from a recent study in an area where water is scarce is shown in table 6.

Table 6. Estimated minimum water requirements (Dangerfield 1983).

Source	Malé, Maldives		Kathmandu, Nepal
	Private well 1/cap day	Piped 1/cap day	Standpipes 1/cap day
Drinking, cooking, dishwashing, house cleaning	7 - 15	15	10,5
Laundering	8 - 10	5	5
Ablutions	20 - 40	44,5	17,5
Toilet flushing			
- cistern flush	15	45	-
- hand flush	8	17,5	2,5
Other uses	-	8	4
Total	43 - 73	90 - 117,5	39,5

4.1.2 Per capita water consumption in a piped supply

Per capita water consumption in a piped supply is usually high and depends on reliability of supply, social and economic conditions, climate and presence of a sewerage system. Examples of domestic water consumption figures are shown in tables 7 and 8.

Table 7. Domestic per capita water consumption in some piped water supplies (Dangerfield 1983).

Place	Country	Domestic per capita consumption l/head/day	Year	Growth in domestic per capita consumption l/head/day/year
Malé	Maldives	40 - 100	1981	
Kathmandu	Nepal	96	1973	
Cairo	Egypt	157	1966	
		181	1976	2,6
Port Said	Egypt	127	1966	
Provincial towns	Egypt	39 - 149	1978	
Provincial towns	Lesotho	107 - 158	1977	
Istanbul	Turkey	119	1976	
Lima	Peru	212	1980	
Santa Cruz	Bolivia	124	1981	
Sucre	Bolivia	98	1981	
Camiri	Bolivia	137	1982	
Paris	France	143	1948	
		159	1978	0,5
Cape Town	South Africa	140	1978	
Amsterdam	Netherlands	91	1948	
		123	1978	1,1

Table 8. Estimated family water consumption in Camiri, Bolivia (family of five persons) (Dangerfield 1983).

Water use	Total consumption 1/week
3 showers/person/day, 20 1/shower	2 100
4 uses of WC/person/day, 20 1/use	2 800
2 hand washing/person/day, 2 1/wash	140
3 meals/family/day, 10 1/meal	210
2 clothes washes/week, 150 1/wash	300
1 garden irrigation/week, 100 1/irrigation	100
1 car wash/week, 100 1/wash	100
1 floor wash/day, 2 1/wash	14
Total per family per week	5 764
Average per capita	165 1/head/day

Figures for one area should not be used for forecast due to the wide variation in domestic per capita water consumption. Hence the need to survey different residential areas separately is evident.

4.2 Surveys

The size of survey will depend on the resources available. For a small supply system 10 % of connections may be covered. In a large city the figure might be only 0,1 % (Dangerfield 1983). In this study a total of 2604 meters was read and this is about 3 % of the total domestic water connections in Nairobi.

4.2.1 Methods of estimating per capita water consumption

If a system of water supply is not metered, the appropriate method would be to measure all the components of the domestic water use, sum them up and divide by the number of household occupants to get the per capita consumption. This would be carried out on samples of the various classes of urban dwellers.

There are advantages and disadvantages of this approach. The advantages occur in the disintegration of the total use. It is easy to study the effect, say, of renovating a dwelling, on the toilet water use for instance by using a small capacity closet. The disadvantage is the inaccuracy of measurement when there is no metering done. This can lead to high values for demand projections.

The metering method is applicable where metered supply is available. Inspection of the consumer meter is made for some time for different types of dwellings. The amount consumed per dwelling in that period is simply divided by the number of occupants and the number of days the supply has been measured. The advantage of this method is simplicity of carrying out the exercise. However, the reliability of the results can be hampered by the inaccuracy in reading the meters and the mechanical failure of the meters. Further, the household, gardening and car washing uses are not separated. These uses should be treated separately where they occur as they can distort the actual per capita water consumption. In both methods the percentage of wastage within the household is included.

The third method involves measuring the amount of water entering an enclosed area and dividing it by the population in the area. This method produces a "gross" per capita water consumption.

Besides including non-domestic uses such as non-metered supplies e.g. fire fighting and illegal connections, this method also counts system losses. These uses are referred to as unaccounted-for water which can also be obtained by the difference between the water supplied to an area and the water used by the consumers either estimated or recorded through metering.

For the purposes of this study, the per capita estimation was done by reading consumer meters and a bulk meter.

4.3 Meter reading results and their use

A total of 650, 1491 and 463 meters was read in Madaraka, Nairobi West and Kahawa West estates respectively. A few meters were found to be mechanically out of order. They showed the same reading after a week. Others showed very low readings, when it was evident that a lot of water might have been used. Normal distribution graphs for the ranges of readings were drawn for each area (figures 4, 5 and 6). The mean of each graph was also determined. This value represented the average household water consumption for the respective area. These graphs also illustrate the accuracy distribution of the meters.

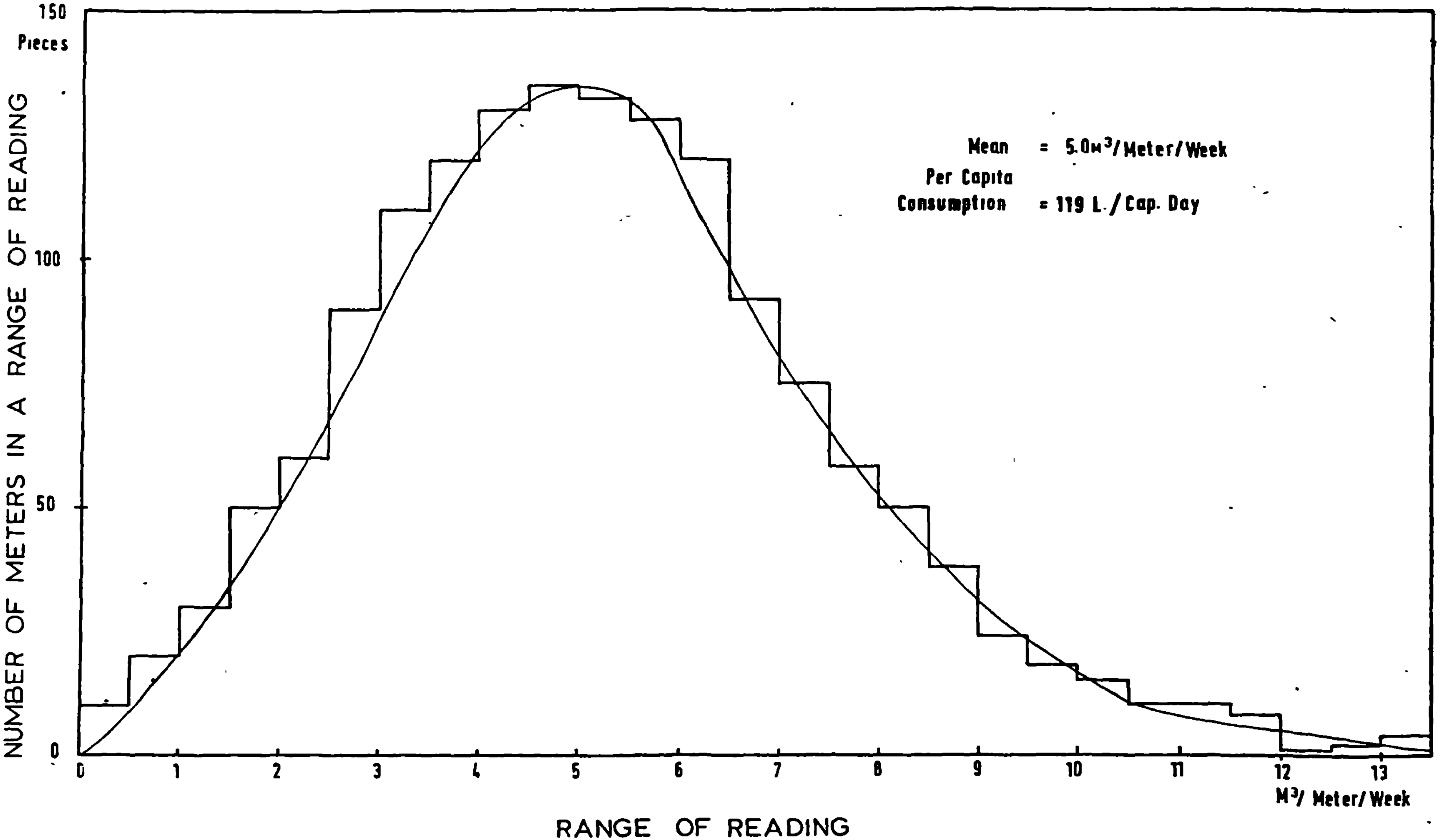

Figure 4. Reading distribution of meters in Nairobi West Estate (17. - 25.10.1985).

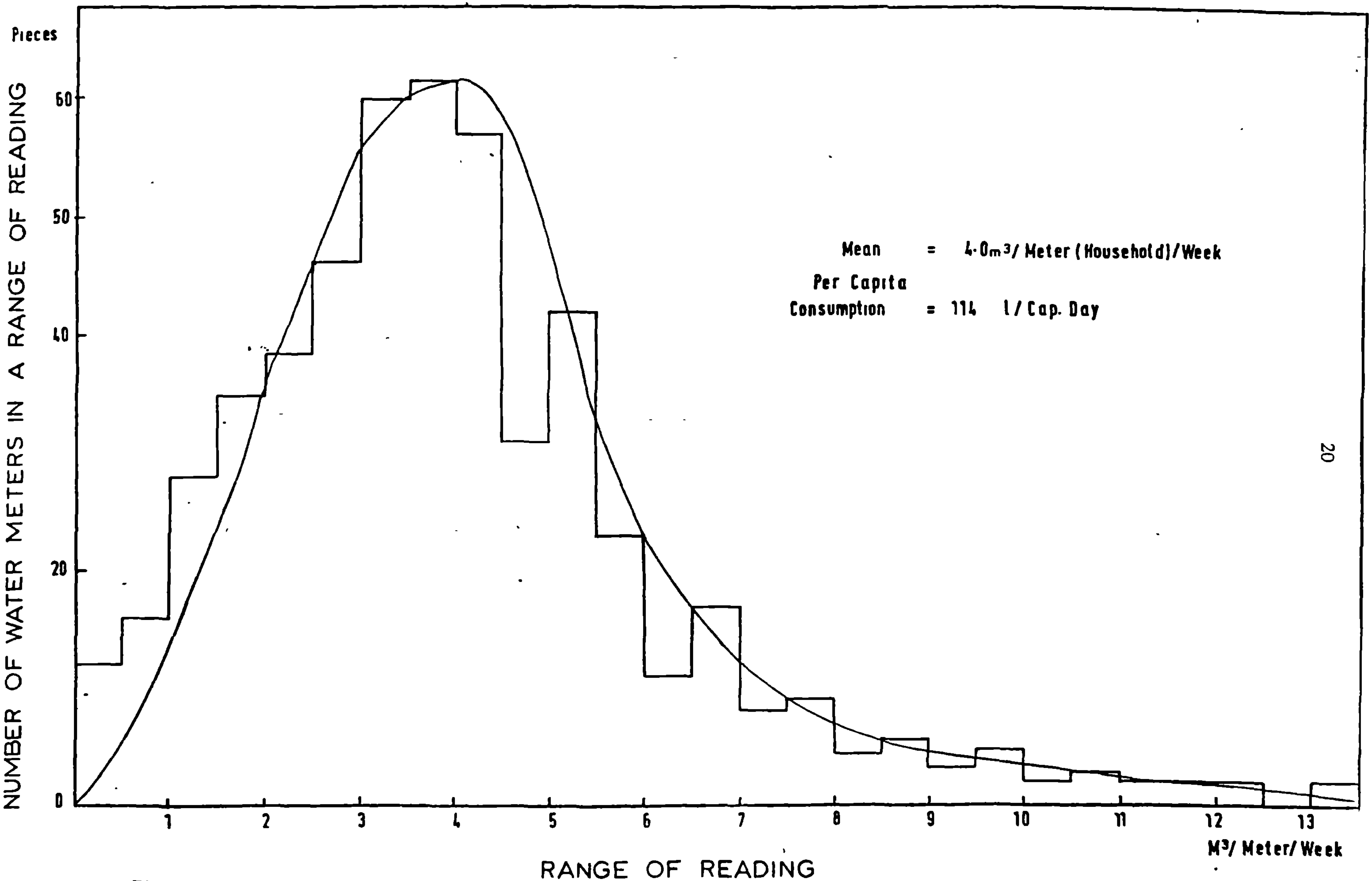

Figure 5. Reading distribution of meters in Madaraka Estate (10. - 17.10.1985).

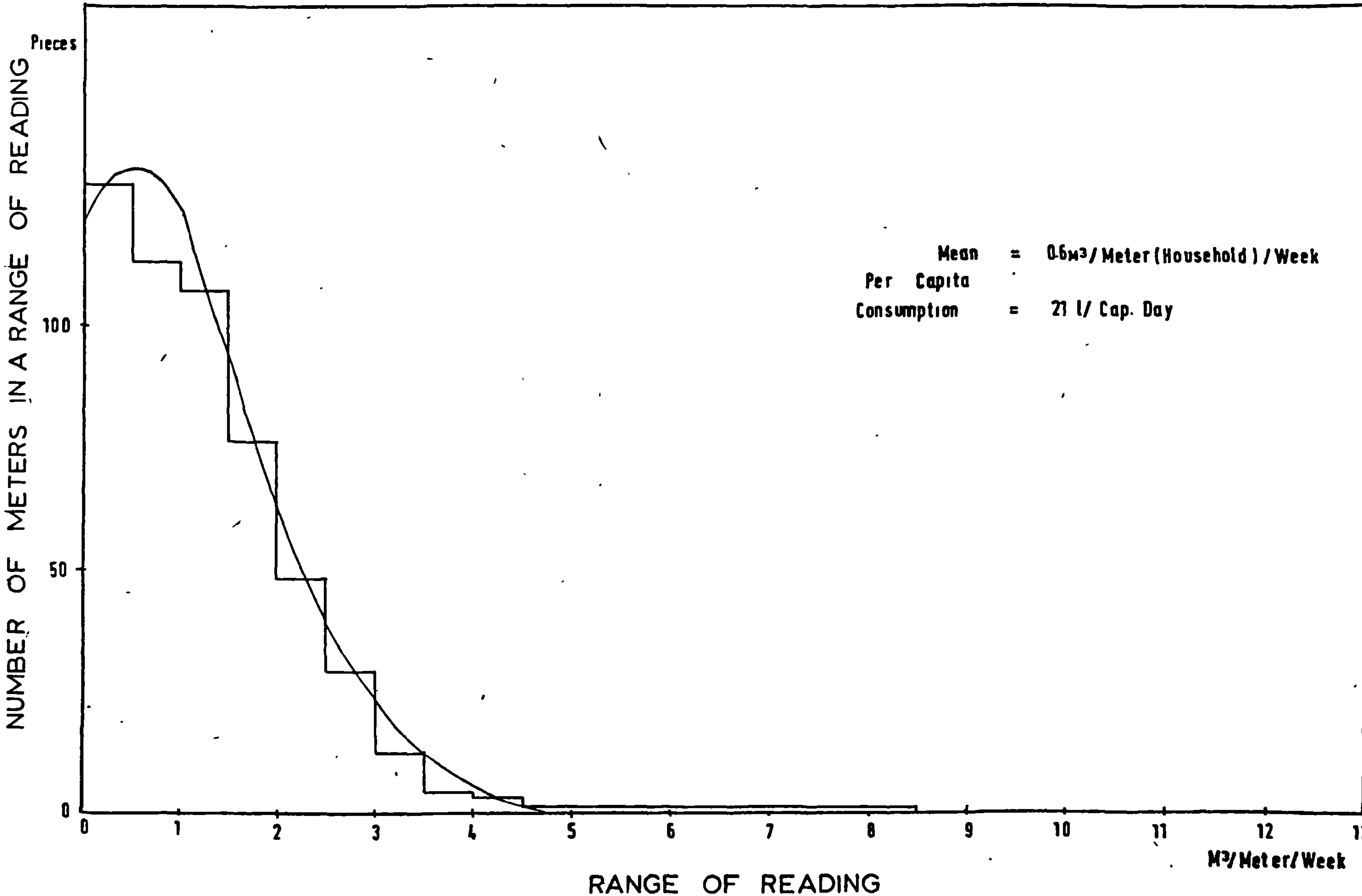

Figure 6. Reading distribution of meters in Kahawa West Estate.

In order to obtain the household occupancy and hence the per capita water consumption, a questionnaire survey was done for each area. The occupancy distribution followed much the same pattern as the meter reading distribution graphs. The mean obtained represented the average household occupancy (figure 7). The average household water consumption divided by the average household occupancy produced the average per capita water consumption.

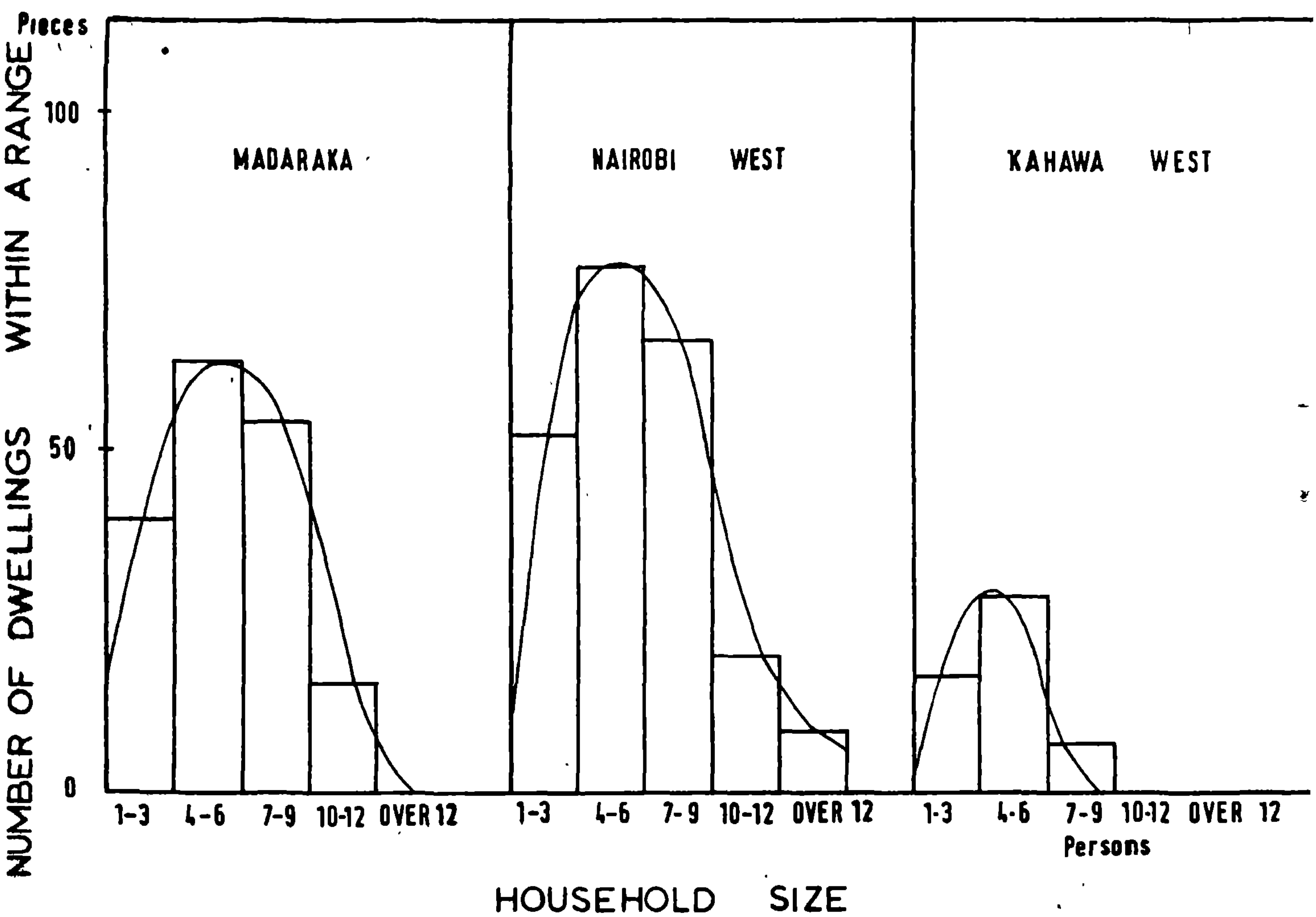

Figure 7. Household size distribution.

Other values of the per capita water use were obtained by dividing the total water consumed and that supplied by the population in each area. The results are shown in tables 9, 10 and 11.

Table 9. Per capita water consumption - "mean" method.

Location	Average household weekly consumption m^3	Average occupancy persons	Per capita water consumption l/cap day
Nairobi West	5,0	6,0	119
Madaraka	4,0	5,0	114
Kahawa West	0,6	4,0	21

Table 10. Per capita water consumption - "total water consumption" method.

Location	Total weekly consumption m^3	Population persons	Per capita consumption l/cap day
Nairobi West	6603	7500	126
Madaraka	4137	3500	169
Kahawa West	736	2000	53

Table 11. Per capita water consumption according to bulk meter results.

Location	Weekly supply m^3	Population persons	Per capita consumption l/cap day
Nairobi West	9900	7500	189
Madaraka	6082	3500	248
Kahawa West	1155	2000	83

Table 12. Summary of per capita values (l/cap day).

Location	Mean method	Total consumption method	Total supply method
Nairobi West	119	126	189
Madaraka	114	169	248
Kahawa West	21	53	83

The per capita values resulting from the mean method are consistent with the expectations bearing in mind the residential category of each location. The other figures do not show any consistency. Attention is drawn to the values from the mean method. These values are nearer to the values sought by this study - actual domestic per capita water consumption. However, the reliability is affected by the following factors:

1) Measuring accuracy

The mechanical fault and the human error in reading the meters could be eliminated. Mechanical faults could be eliminated by periodical meter checks and testing.

2) Time of measurement

The values obtained were a result of a one-week survey for each area during the cool months of October and November 1985. If measurements were done on similar lines for one year, a more reliable average per capita value would be obtained.

3) Extent of measurements

To come up with representative values for all residential areas in a city like Nairobi, there is need for separate measurements for different locations. This would require more labour hours. For example Nairobi West Estate required eight meter readers and one foreman for two days in the week. Many more would be required to cover the whole of Nairobi. Analysis of the results would even be aided by a computer. But all this exercise would be justified in view of the improved reliability of per capita water consumption values obtained for demand projections.

4) System reliability

Nairobi West and Madaraka estates have fairly reliable water distribution system. Consumers experience fewer water supply failures as was found out by the questionnaire survey. The results obtained in the study were in essence reliable on the basis of system soundness. On the other hand, Kahawa West experiences intermittent water shortages. The leakage level is in the range of 40 - 50 %. The very low per capita value obtained by the mean method is explained by this state of affairs since much of the supplied water does not reach the consumer. As such this value cannot be depended upon. A more reliable figure can be obtained by estimation of different household use. But the value obtained by the total supply method is nearer what can be expected from such an area but then this figure includes the leakage and hence it cannot be used for any serious projection.

A good maintenance programme would address itself to reduction of leakage. Knowledge of the leakage level requires good metering practices devoid of any inaccuracies. Hence of paramount importance in this area is:

- meter checks after a period of time,
- assessment of the number of meters not functioning correctly with recommendation for an effective and efficient maintenance and replacement programme,
- checks on the performance of meter readers.

4.4 Comparison between calculated and handbook values of per capita water consumption

Some adjustment of the per capita values under consideration remains to be done before they can be compared with the ones currently being used. The four factors considered earlier - measuring accuracy, time of measurement, extent of measurement and system reliability - all have an effect which can add to or reduce the measured value. It can safely be assumed that the values remain the same after the net effect of the factors. They will thus be compared to some recorded values.

In chapter 1 it was mentioned that Nairobi West, Madaraka and Kahawa West fall approximately into housing types I, II and III respectively defined in the same chapter. The water demands and projections proposed by the consultants (Howard Humphreys) for the three residential areas are set out in table 13.

Table 13. Per capita water demand by residential categories (Howard Humphreys 1985).

Type of housing	Demand l/cap day		
	1985	1995	2010
I	210	230	245
II	115	130	145
III	50	60	75
IV	15	25	30

The design per capita water consumption values used by the Water and Sewerage Department of the Nairobi City Commission are shown in table 14.

Table 14. Per capita water consumption and house occupancy (Nairobi City Commission, Water and Sewerage Department 1983).

Residential category	Per capita consumption l/cap day	Average number of occupants per house	Average daily demand per house l
High income (I)	273	4,0	1091
Medium income (II)	136	6,5	886
Low income (III)	60	7,6	458
Squatters (IV)	18	-	-

The results obtained by this study are quite comparable with those from other sources which had been obtained by more thorough methods. It can safely be concluded that the steps followed in the study produced similar values to the ones in other studies.

Table 15. Comparison with recorded values.

Residential category	Department's values (1983) l/cap day	Howard Humphreys (1985) l/cap day	Study (1985) l/cap day
High income (I)	273	210	119
Medium income (II)	136	115	114
Low income (III)	60	50	(21)
Squatters (IV)	18	15	-

5 FACTORS AFFECTING AND VARIATIONS OF DOMESTIC WATER USE

5.1 Factors affecting water use

There are six factors which affect the amounts of water withdrawn by individual households thus causing the variation of water consumption between households. These are the size of family, income level, education, cultural heritage, character of water supply, cost of obtaining water as measured by energy or cash expenditure, climate and terrain. Per capita withdrawal is regarded as a function of all these (White et al 1972). The same combination of factors is related to the total household use. Generally the domestic users can be divided into those carrying water and those with piped connections. Attention is focussed at those factors which affect household water use with piped connections since the study areas fall within this group of users.

5.1.1 Households having piped connections

Among households having water piped into the houses, six factors are associated with total and per capita use.

1) Water use in gardens
   Households with gardens obviously use more water per capita than those without. In a city like Nairobi, gardens are maintained only by the high income group of people. Housing for middle and low income groups make no provision for gardening.

2) Household composition
   Household composition is an indication of what the population of a dwelling consists. According to a study made by White et al (1972) the number of children is inversely related to the aggregate total use. Also as the number of children increases, per capita consumption figure decreases. Increase on the number of servants, on the other hand, increases both the per capita and the total use.

3) Housing density

Housing density as a measure of material wealth is inversely related to the per capita water use; the lower the density of the buildings the higher the use.

4) House size and facilities

The number of water using fixtures, e.g. baths, showers, toilets and heaters, in a household is a good measure of per capita household water use. Introduction of a heater in the house is linked with expansion in use. Inclusion of such heaters and baths in some houses also denotes class of people living in them and hence the per capita use of water.

5) Education

The education level of members of the household is directly related to per capita and total water use in households. But education does not, however, vary in the same way as wealth, as measured by housing density or water heaters.

6) Cost and price

There have been conflicting reports how price of water affects domestic water demand. Howe and Linaweaver (1967) found out that household demands are relatively inelastic to price but sprinkling demands are quite elastic with respect to price in some parts of USA. Dangerfield (1983) also says that there is evidence which suggests that effect of price on demand of water is relatively small so that it is probably safe to neglect it. The need to use price of water to regulate demand may, in any case, be limited by the need to encourage adequate use by poorer sections of the community without imposing too heavy a financial burden on them. The Water and Sewerage Department in Nairobi has no evidence to assume that price effects on demand would be other than minor and temporary (Nairobi City Council 1977).

However, it is generally felt, with justification, that low income people are more sensitive to increasing prices of water and tend to reduce use. The ability to pay for water varies with income of the consumer.

The questionnaire survey conducted during this study showed generally that most consumers thought that the billed amount did not reflect the amount of water used. One explanation to this would be that the amount had suddenly appeared very big and they had thus suspected the meter reading. It is noteworthy that the prices had been increased recently (appendix 8).

7) Metering and system design

Where metering has been introduced in houses with multiple taps it has accounted for 20 - 40 % reduction in water use within the household (Hanke and Flack 1968). Since somebody is charged for what is measured by the meter, the effect is psychological - to reduce usage when the water bill becomes intolerable.

During the questionnaire survey conducted for this study it was realised that a lot of consumers had lost confidence in the routine meter reading exercise by meter readers of the Water and Sewerage Department. A majority was billed excessively. This is the fault with the billing system and improvement in meter reading and repair of the same are highly recommendable.

5.1.2 Households having unpiped water supplies

Unpiped supplies include water taken from standpipes, tankers or handpumps. Factors affecting water consumption from standpipes are:

- whether water is free of charge,
- where laundering or bathing is allowed at the standpipe,
- measures taken to prevent wastage,
- distance to the standpipe,
- number of people using it.

Further analysis of these factors is beyond the scope of this report as it concentrates more on piped supplies.

5.2 Time aspects of domestic water use pattern

The per capita or even the total domestic water consumption does not remain constant but fluctuates with time and season. Three classes of fluctuations have been recognized:

1) hourly variation,
2) daily variation,
3) seasonal variation.

5.2.1 Hourly and daily variations

Patterns of daily and hourly domestic water use were obtained after measurements in the study area and are shown in figures 8 to 12.

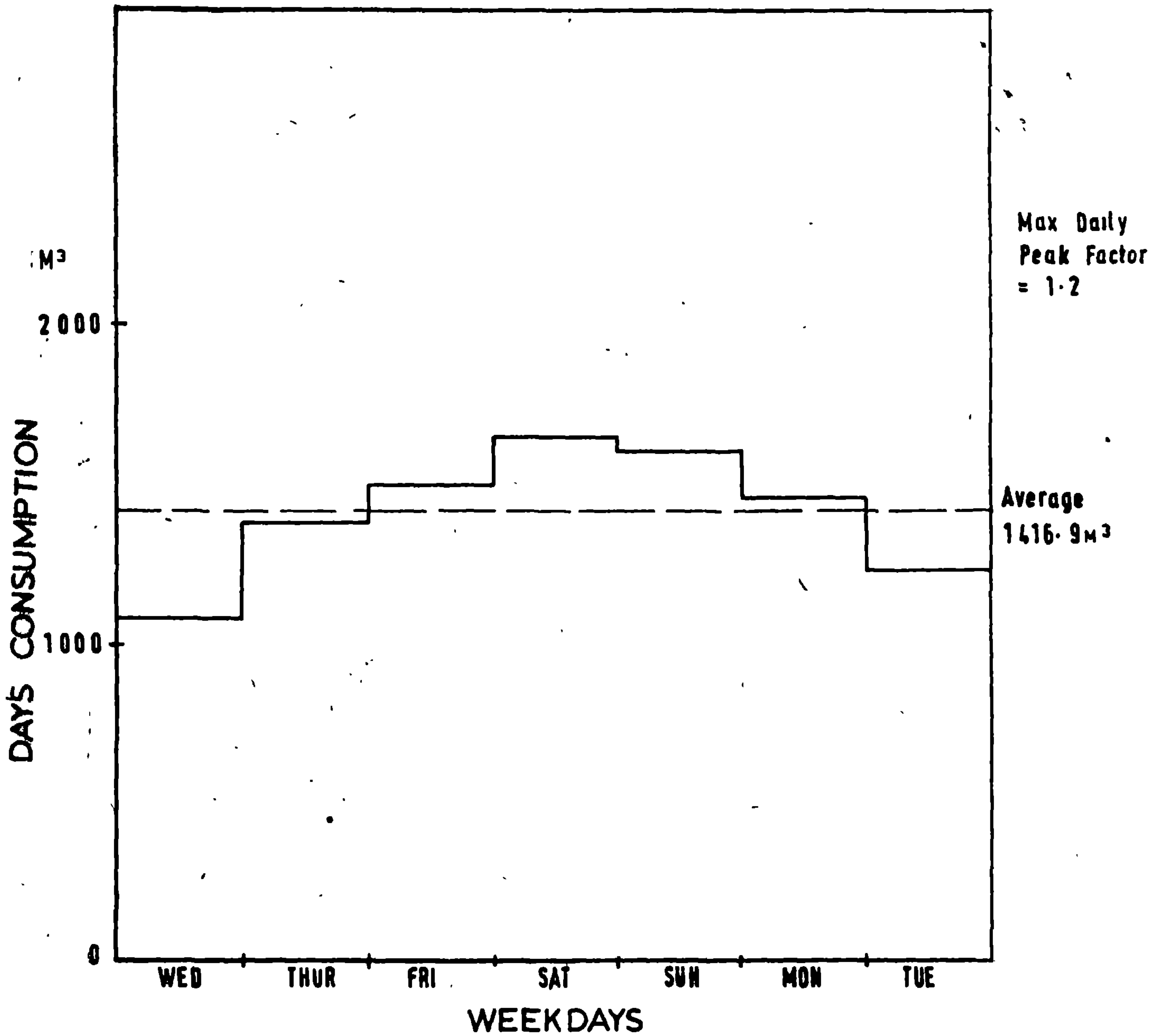

Figure 8. Daily consumption in Nairobi West Estate (2. - 8.10.1985).

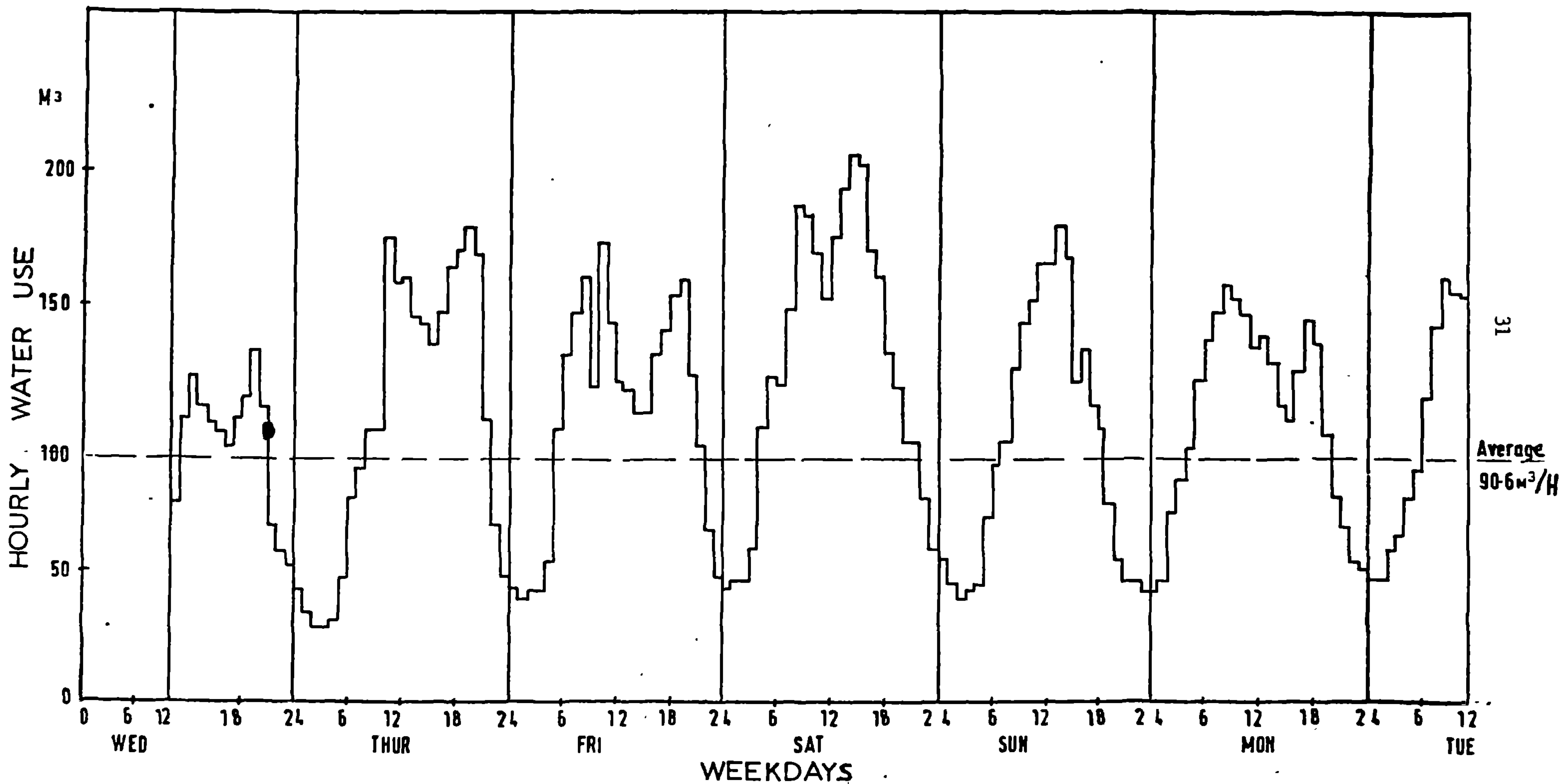

Figure 9. Weekly pattern of hourly water use in Nairobi West Estate (2. - 8.10.1985).

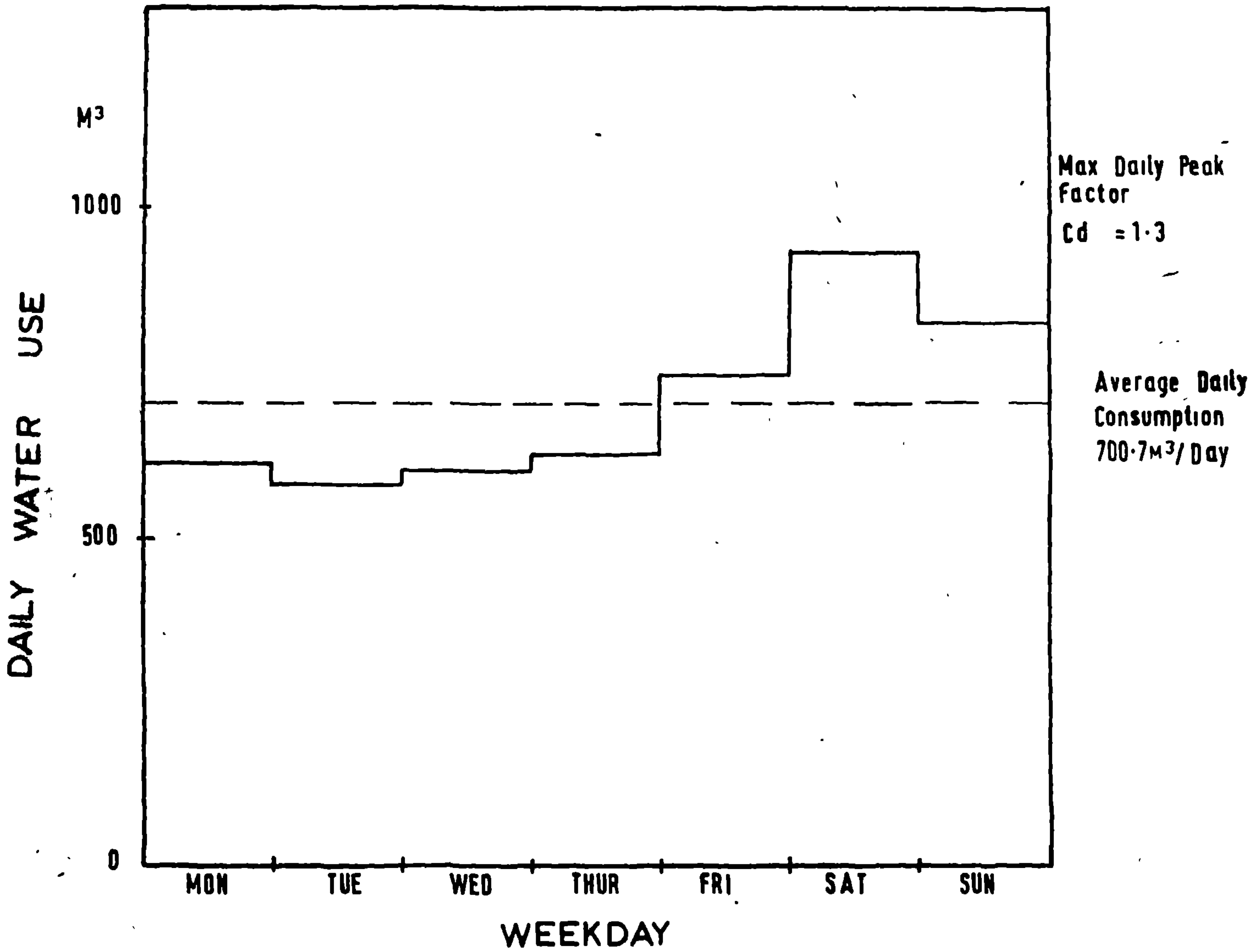

Figure 10. Daily water use in Madaraka Estate (12. - 19.10.1985).

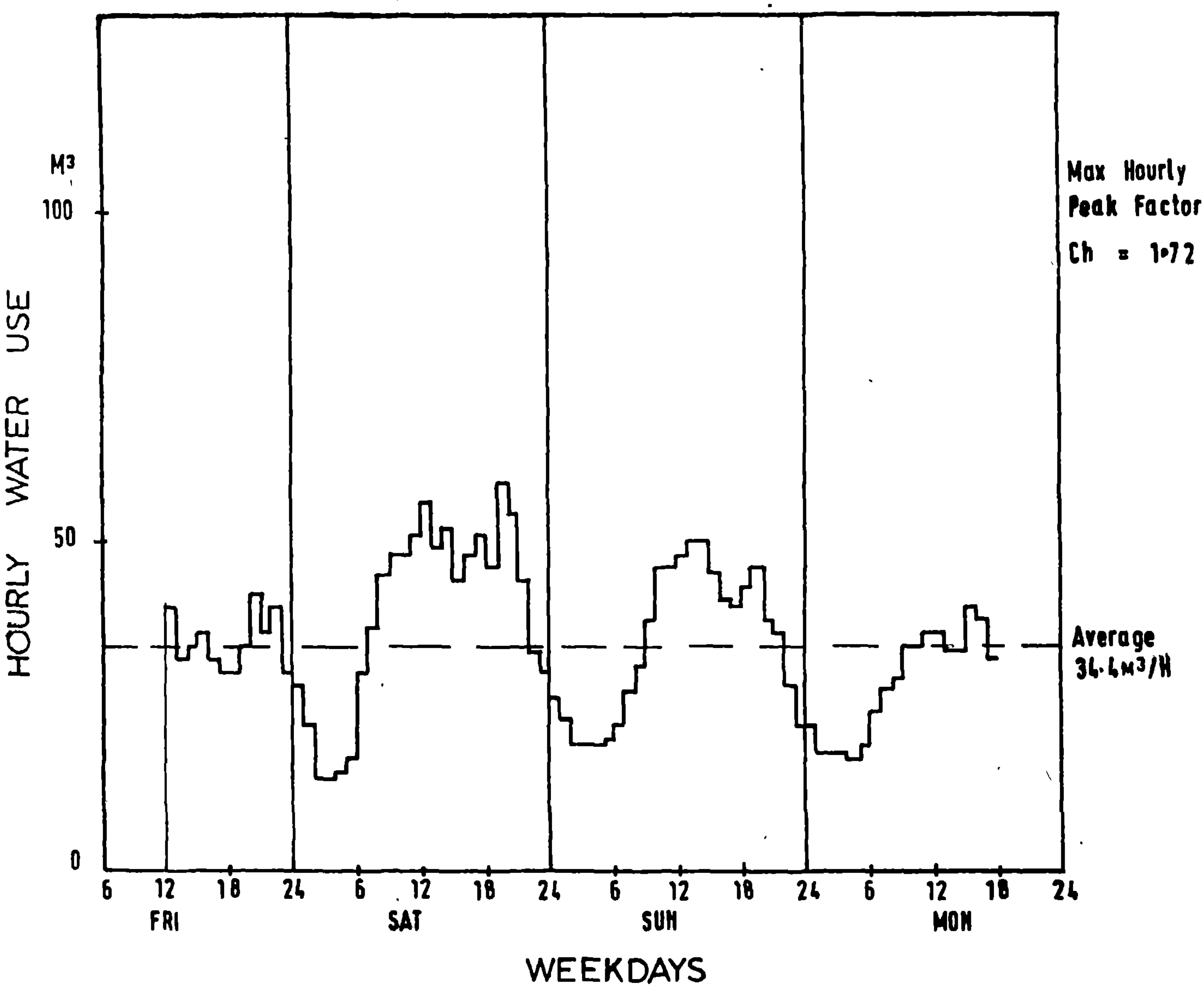

Figure 11 . Hourly water use in Madaraka Estate (12. - 15.10.1985).

Of the data compiled from a water system analysis, those dealing with peak day and peak hour demands are of particular interest. Peak factors are obtained by dividing the peak demand by the average demand.

Maximum hour and maximum daily demand requirements have an important influence on utility's costs. Because water utilities must meet all the demands of their users, water systems are usually designed to meet peak demands. Hence it is important to evaluate peak factors for all classes of consumers. These are called class peaking factors (Barden and Stepp 1984).

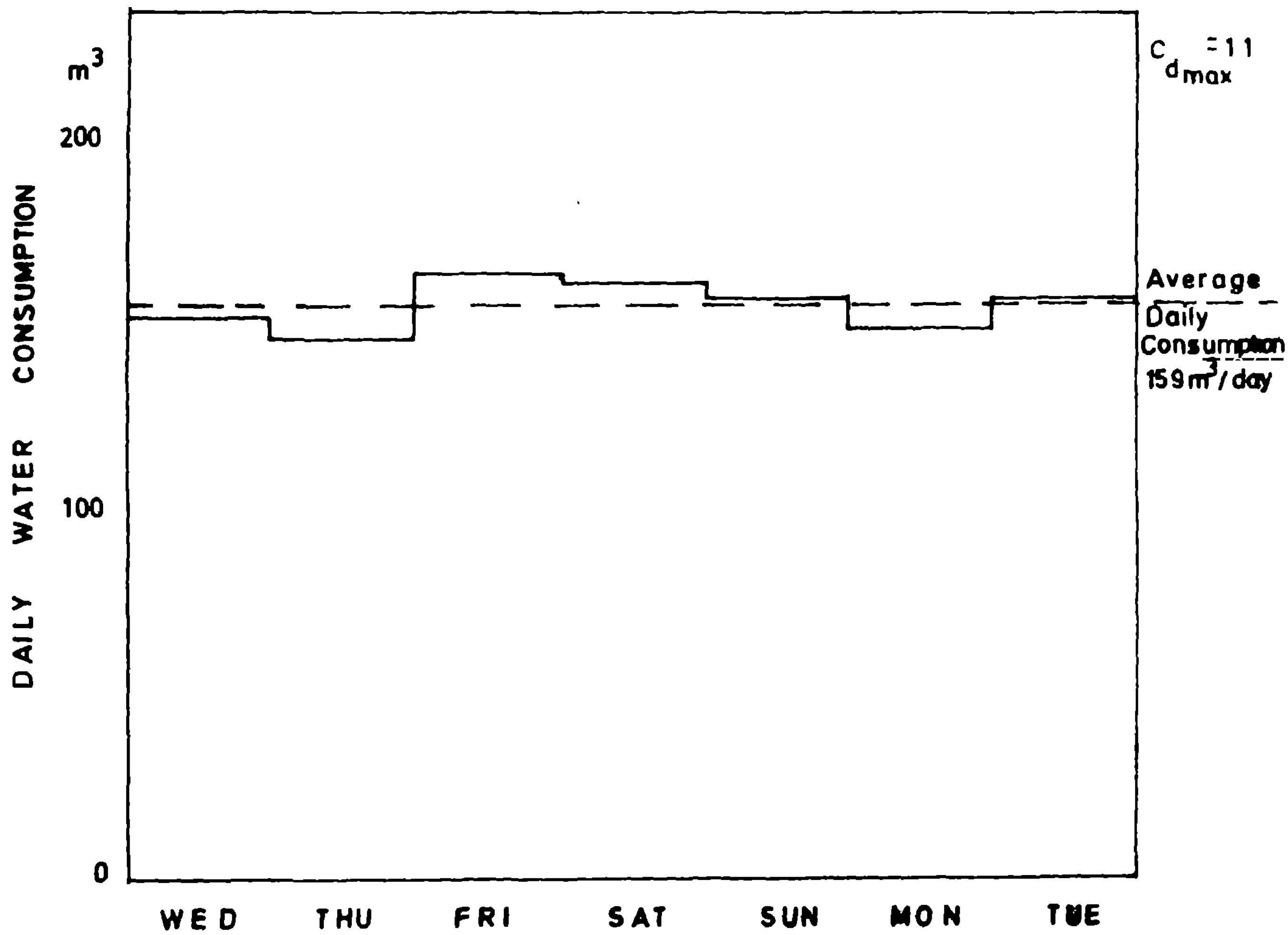

Figure 12. Daily water consumption in Kahawa West Estate (4. - 10.12.1985).

5.2.2 Seasonal variation

Where lawns and gardens are not a major use or where the lawn applications continue throughout the year, the seasonal fluctuations are less pronounced and may not be so significant. This is because lawn application represents a consumptive use and varies with seasons (White et al 1972). Examples of seasonal variation in domestic demand are given in figure 13 and that for the years 1984 and 1985 in figure 14 for the city of Nairobi.

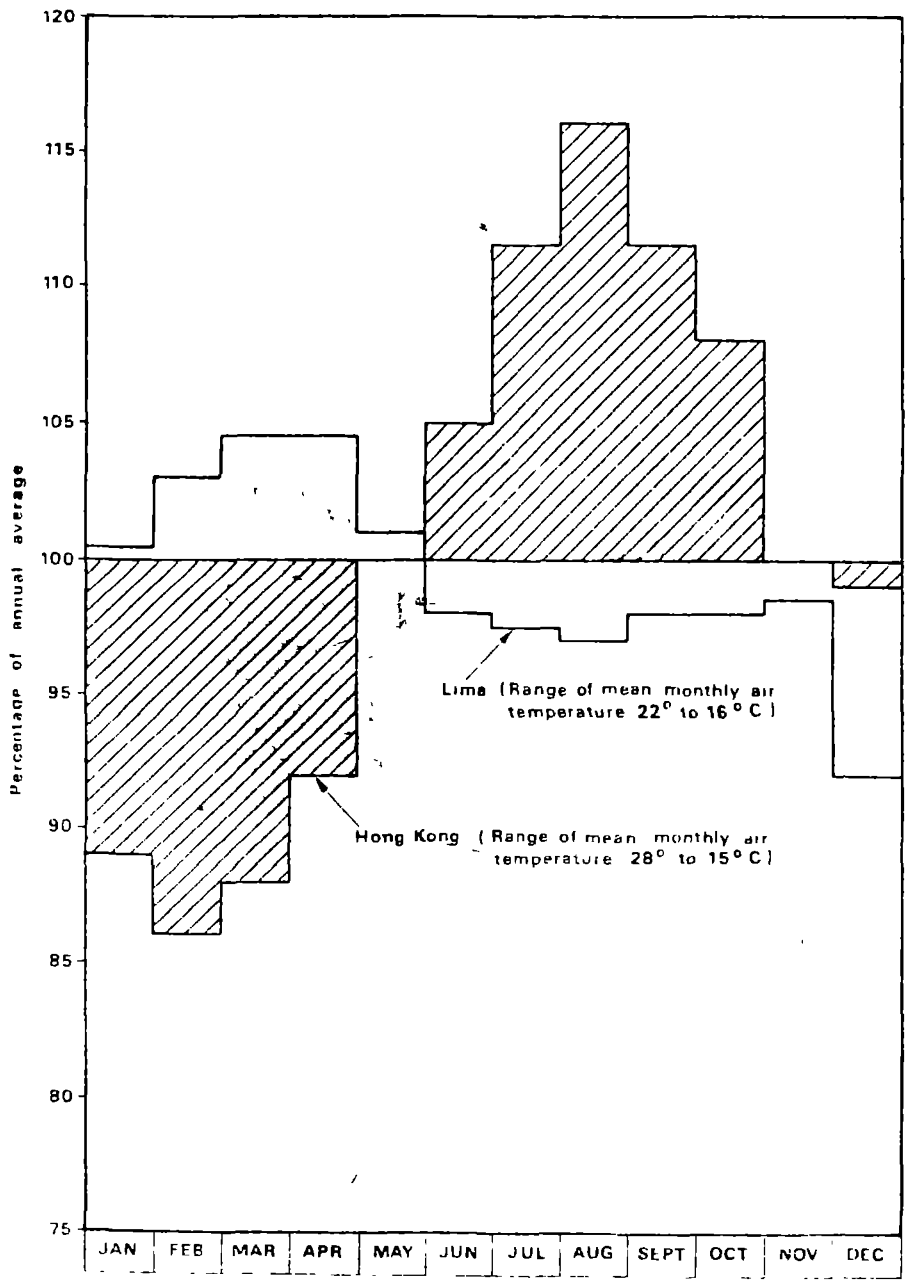

Figure 13. Examples of seasonal variation in water demand (Dangerfield 1983).

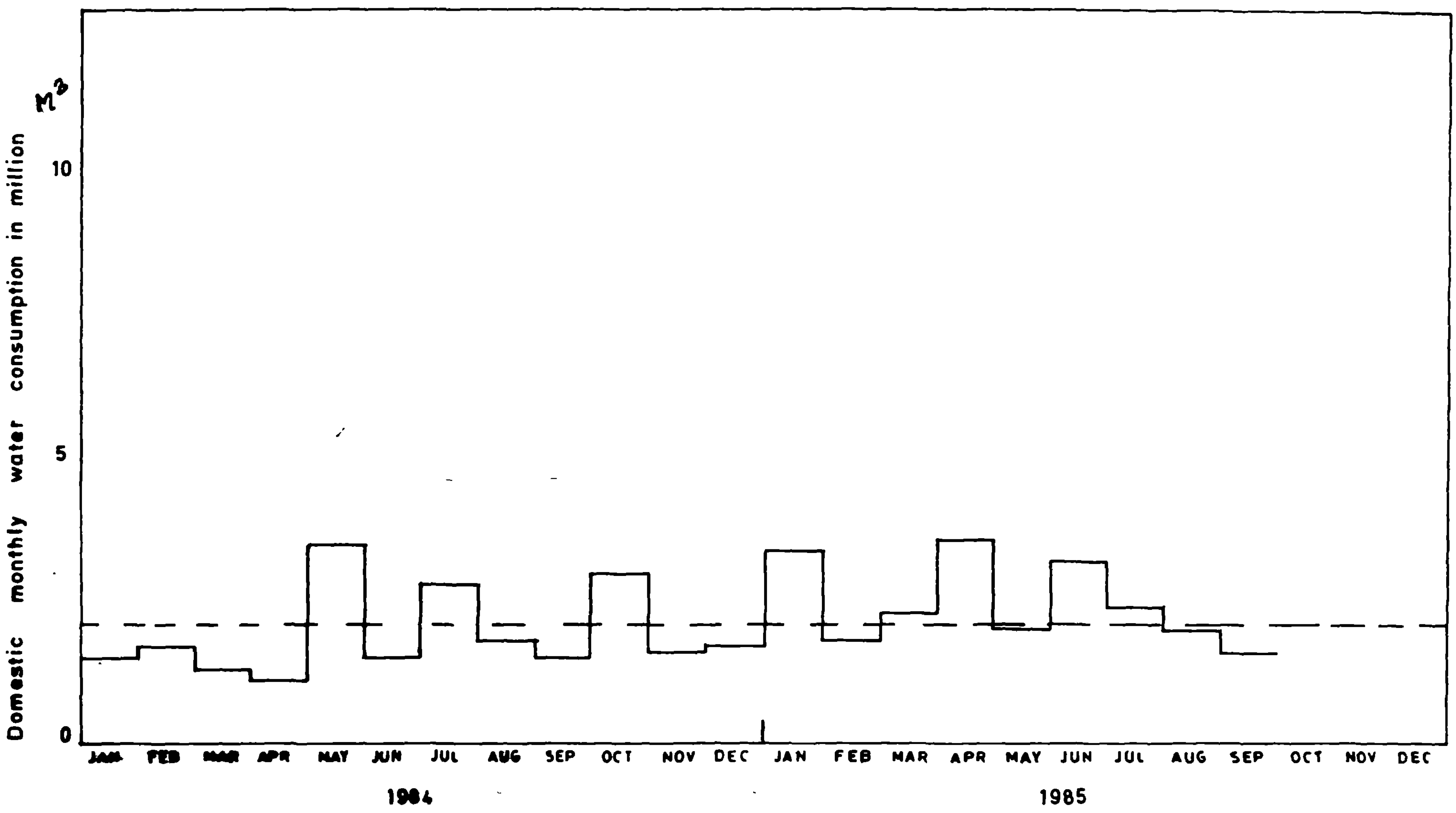

Figure 14. **Recent monthly variation in domestic water consumption in Nairobi**
(Data from water billing cycle, commercial section, Water and Sewerage Department, N.C.C.)

There is no notable pattern in variation. Hence the doubts cast over the reliability of the billed amount of water used. For example there is a sharp contrast between the amounts for April 1984 and 1985.

Lawn sprinkling in Nairobi is generally not a major use and as such seasonal variation does not depend on it. Comparison between water balance and domestic use at some Nairobi sites is shown in figure 15.

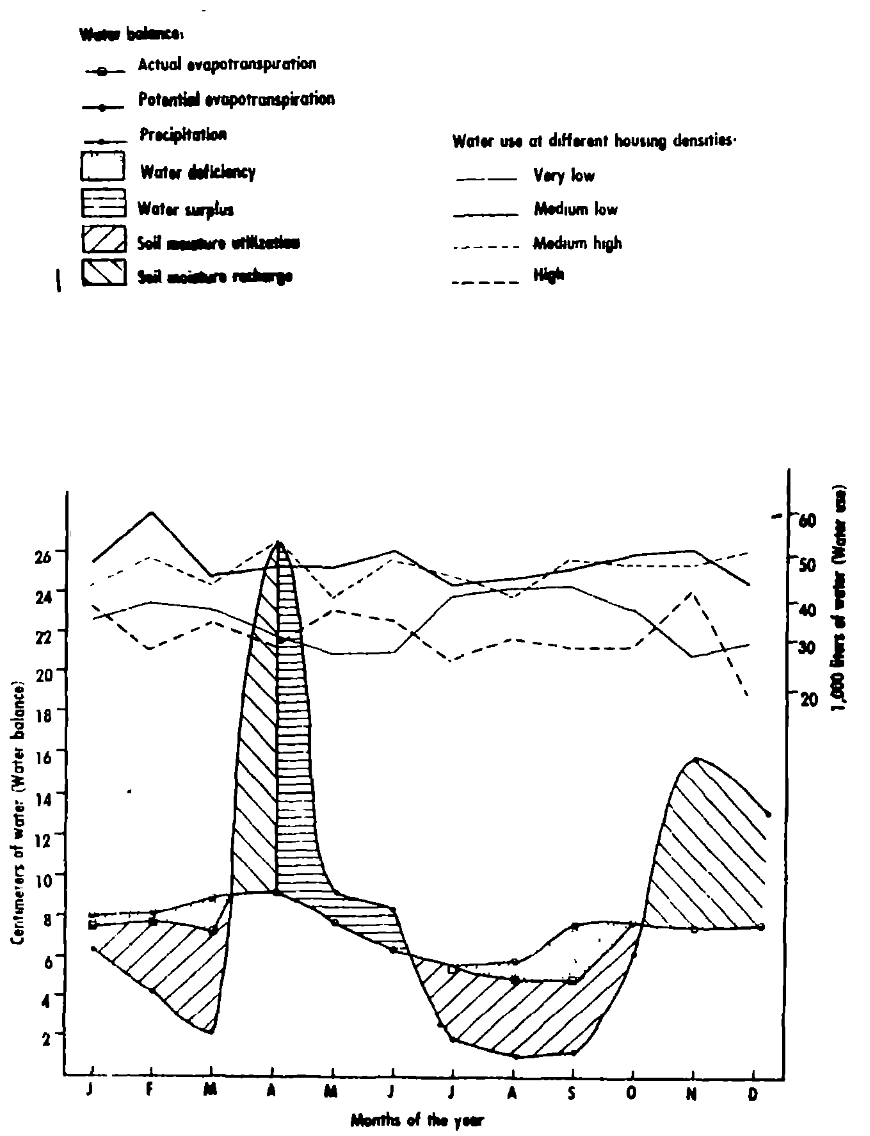

Figure 15. Water balance and domestic water use at Nairobi sites (White et al 1972).

5.3 Peak factors

The maximum daily and hourly peak factors deduced from figures 9 to 12 are set out in table 16 below. The peak demand factors were then calculated according to the formula

$$C_{max} = C_{dmax} \times C_{hmax}$$

where C_{max} = peak demand factor

C_{dmax} = maximum daily peak factor

C_{hmax} = maximum hourly peak factor

The same was repeated for minimum peak factor, $C_{min} = C_{dmin} \times C_{hmin}$.

Table 16. Peak and minimum demand factors.

Location	C_{max}	C_{min}
Nairobi West	2,53	0,23
Madaraka	2,23	0,31
Kahawa West	*	*

* Only daily meter readings were done for Kahawa West. The maximum peak daily factor was 1,1.

In comparison the design peak factors used in the past by the Water and Sewerage Department of Nairobi City Commission are shown in table 17.

Table 17. Design peak demand factors (NCC 1983).

Category	Peak demand factor	Minimum demand factor
High income	2,00	0,3
Average and low income	1,75	0,3
Commercial areas	1,75	0,2
Industrial areas	1,15	0,5

The peak values obtained from the study are quite comparable to the design values. The area chosen in both cases has an effect, with the highest value corresponding to the high income area. This is because the volume of water consumed during the peak hours is relatively high due to availability of many taps and water appliances and the possibility of their simultaneous use.

The calculated values are just one set of values which would be required to obtain an average figure which can be used for design. Only after similar studies are done for all types of residential areas, and for other categories of consumers and for longer periods, can the values be of a more reliable nature. Minimum factors are especially useful in analysing leakages. The level of leakage determined by the method of minimum night flows was found to be about 20 % and 30 % in Nairobi West and Madaraka estates respectively. By using the difference between bulk meter and overall consumer meter readings, the leak detection team found the leakage level to be 23 % and 32 % for the two areas respectively during the same period. The peak factors are important in the design of future distribution systems to meet the peak demands. The inability of a water system to meet the peak hour demand focuses attention on the causes and recommended solutions to the specific problem.

6 WATER CONSERVATION PRACTICES

6.1 Benefits from conservation practices

The factors which necessitate water conservation are:

1) increasing costs of raw water development,
2) higher standards of treated drinking water,
3) scarcity of supply exacerbated by drought.

A water conservation programme provides direct benefits to the utility and to the consumers, for example (Flack 1981):

1) Pumping costs are reduced.
2) System expansion is slowed down.
3) Life of the existing capacity is increased.
4) Water treatment benefits result from reduced energy and chemical costs.
5) If there are reduced utility operating costs and lower plant investment expenditures, the consumer will experience reduced water bills.
6) Costs in wastewater treatment are decreased.

6.2 Methods of water conservation

Water conservation practices can be classified into two types: consumer oriented and utility oriented consisting mainly of leakage control (Gagnon 1984).

6.2.1 Consumer oriented or structural methods

Consumer oriented or structural methods include metering, public education programmes, flow control devices inside the house, e.g. low flow shower heads and low volume toilets and recycling systems.

6.2.1.1 Metering

Metering means that people pay for water according to the volume used. There are many charging systems, described subsequently, but all have the same goal - to charge for all the water used. The control is psychological - using a lot of water means paying more. It is everyone's own decision how much water to use. The possible difficulties with metered systems are:

a) The meters may not function well, resulting in inaccurate measurements, loss of consumer confidence and unending complaints towards amounts to be paid.

b) The meter may not be read properly. This occurs especially when the meters are inaccessible and are covered with rubbish. The meter reader would use his judgement to approximate the consumption.

c) A good metering system is expensive and complicated to operate and would require regular meter testing and repair programmes. Accuracy of the utility's meters is critical to the efficiency in utility operation. Meters determine the basis for determining utility income, making operational decisions in response to fluctuating demand, planning improvements and determining the amount of unaccounted-for water.

The questionnaire survey conducted in this study showed that consumer confidence in meter reading has been eroded. This has stemmed mainly from inaccurate meter reading.

6.2.1.2 House water-using fixtures

Consumers can install water-saving devices, such as low volume water closets, flow controllers and recycle systems into their houses. Water saving devices include plumbing fixtures and appliances that accomplish the same function as a standard equipment but use less water. Flow controlling devices reduce pressure in the individual residence. A possible way to re-use water is to use wastewater from baths and dishwashing for flushing toilets. For those people with gardens at their dwellings, the use of improved sprinling equipment can reduce water used for their gardens.

6.2.1.3 Public education or socio-political methods

Public education regarding conservation techniques is necessary in any demand reduction programme. Instruction in how water is used and how various conservation alternatives would work are the keys to the success of the programme. An example of an appeal made to the public by the Water and Sewerage Department in a time impending drought went as follows:

- Use less, waste less.
- Avoid washing clothes, utensils, hands etc. under a running tap. Wash them in a bucket, sufuria or basin.
- Stop watering the garden.
- Stop unnecessary flushing of toilets.
- If you have to wash a car, use a bucket, not a hose.
- Fix all leaking taps immediately.
- If you are an employer, publicise this appeal to save water to your employees.
- Report all pipeline leaks to the department.

These are voluntary restrictions which later on may become mandatory.

6.2.2 Utility oriented or operational methods

Leakage detection and repair and the implementation of water use restrictions are the major operational means of water conservation.

6.2.2.1 Leakage detection and repair

System leakage is responsible for large quantities of unaccounted-for water in urban areas. Leakage repair improves the system efficiency and increases water availability. The consumer's confidence in the water undertaking authority is elevated and therefore can respond positively to the water conservation campaign. The losses can be controlled to a minimum by means of a proper programme of waste detection and control, but the existence and magnitude of the problem will only be apparent if there is a well organized routine for monitoring flow throughout the system. The consumer can implement the operation technique of demand reduction by leak repair at his dwelling. As was gathered by the questionnaire survey, leak repair after the meter towards the house is the houseowner's responsibility. However, there are still some consumers who believe it is the responsibility of the water undertaker and would leave a leaking pipe connection unattended.

6.2.2.2 Water use restrictions

Water use restrictions for different categories of use are a common conservation technique. Domestic water use restrictions may be specifically addressed to exterior water uses such as garden sprinkling, car washing and filling of swimming pools or, in more serious instances, rationing of water supply.

6.2.3 Economic methods

Economic methods of demand reduction can be accomplished by the utility's pricing policy, incentives, penalties and demand metering. There are many types of pricing governed by the tariff structure: a constant unit price, increasing block rate, declining block rate and flat rate. Incentives would take the form of rebates, tax credits or other rewards for conserving water. Penalties or fines can be imposed for wasteful use of water. Demand metering is a pricing mechanism based upon the measurement of incremental volumes of water in relation to the time of use. This is expected to encourage reduced usage during the peak demand period (Flack 1981).

Among the tariff structures, the constant rate and the increasing block rate are of the water conserving nature.

6.2.3.1 Reducing demand by pricing

If the price of water did not have any significant effect on demand, the pricing decisions by utility managers would be concerned with only two objectives (Howe and Linaweaver 1967):

1) to generate sufficient revenues from the sale of water to cover costs; that is rates would be obtained by dividing the system costs by the volume of water delivered,
2) to raise revenues in accordance with some concept of "equity" among the consumers.

But due to occasional shortages, most water concerns have included the element of conservation into the pricing system. Predicting the impact of a new rate structure or new prices for the same structure, on consumption and revenue, presupposes information about the sensitivity of demand to price changes (price elasticities). This information is rarely available and is also subject to change over time (Comer and Beilock 1982). The tariff structures in Kenya are always described by a number of characteristics:

a) number of steps,
b) level of each step,
c) whether the minimum charge is to be imposed,
d) special costs, e.g. connection costs, meter rent etc.

Examples of the current and previous tariff structures adopted by the Nairobi City Commission are shown in appendices 8 and 9 respectively. These two similar tariff structures are examples of a two step system with a minimum charge.

If the price of water is expected to help in a water conservation programme, then the typical demand curve shown in figure 16 would be expected to result.

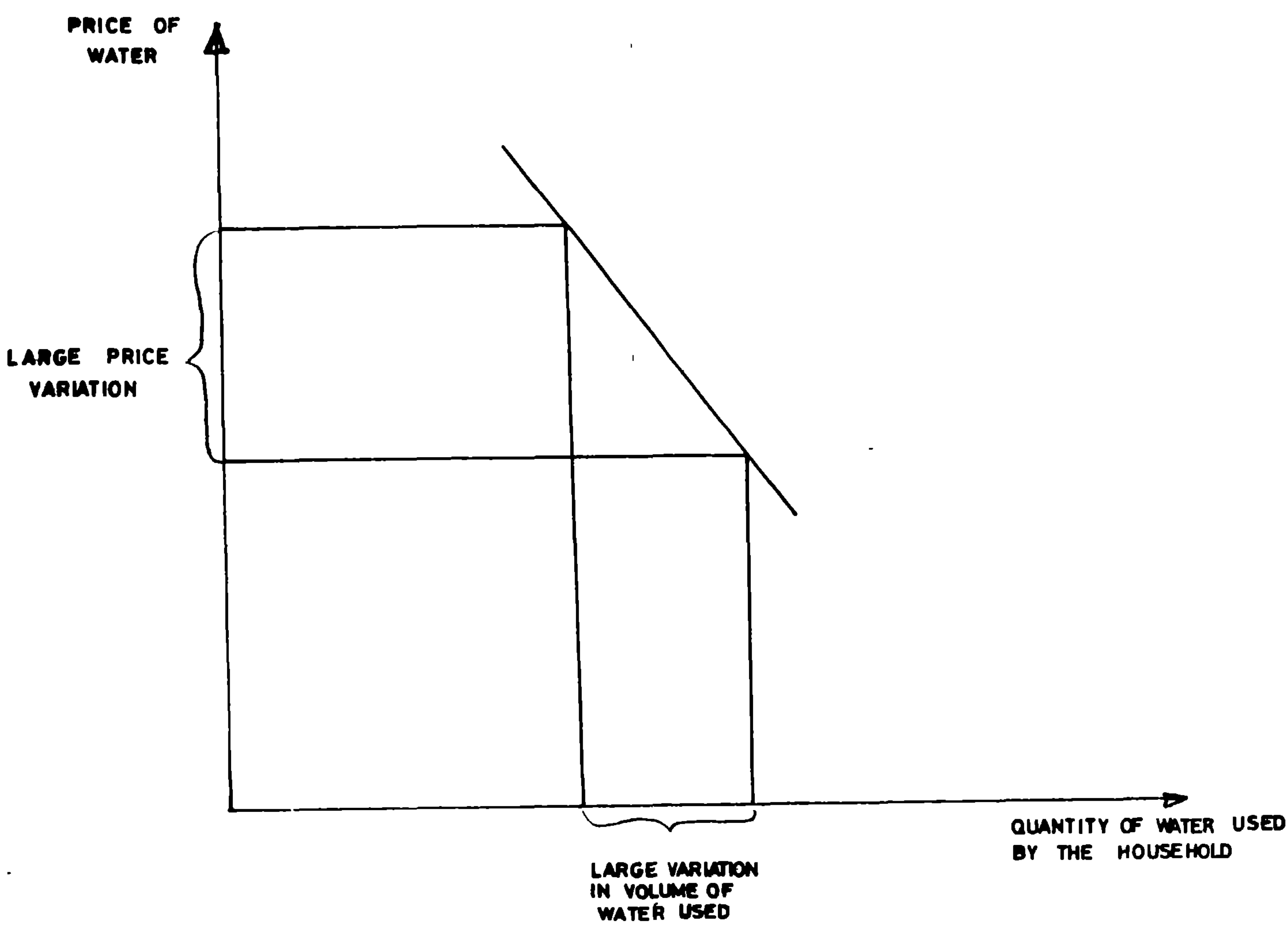

Figure 16. Expected water conservation demand curve.

The gradient of the curve is the price elasticity of demand. The lesser the negative the better for any conservation programme. This assumes that no other factors would increase the demand, e.g. the household population.

7 DISCUSSION

The advantages of regular monitoring of not only domestic water consumption but also other water consumptions are many. Besides providing very reliable data for future projections, monitoring arouses attention to a water supply system performance either for the whole city or a section within it. The day to day or even hourly measurements of the water use by any category of consumers, the analysis of the variations and factors affecting consumption as well as evaluation of available conservation methods are among the methods of monitoring water consumption.

Nairobi is currently being supplied by about 217 200 m^3 of water per day. In the first according to analysis of the billing records, domestic water consumption has averaged 50 % of the total water supplied. This figure results from totalling individual consumer amounts as recorded by the water meters. Thus the system leakage is not included except that occurring within the household and is measured as a part of the domestic consumption. However, with increase in rate of housing development the domestic percentage is bound to increase to 60 % by the year 1995.

Despite the suspicion cast over the NCC billing records, they provide the only readily available data. From these records, the average domestic per capita water consumption has been found to decrease from 82 l/cap/day in 1975 to 72 l/cap/day in 1984. This has been attributed to supply constraints. Again these figures exclude the system leakages. With anticipated reduction in water shortages, leak detection and repair, the per capita consumption is set to rise to 90 l/cap/day in 2010. The average design value is about 125 l/cap/day basing it on the population forecast for 1985 for the whole city. Unfortunately for this study, the population figures from the Kenya's Central Bureau of Statistics could not be used because these follow administrative boundaries which may include several residential areas. The questionnaire survey was chosen as the method to provide the present estimate of population in the study areas. Accuracy in population forecast affects the final per capita water consumption figure obtained by any analysis.

The reliability of the data obtained during a monitoring programme depends on methods used, extent of the source of the data and the time of measurement. In this study metering practice has been singled out as the method which can provide the desired data such as the per capita water consumption figures and the peak factor for the different consumer categories. It is ideally desirable to obtain separate data for different areas of a city like Nairobi. Generally the housing classification also follows the income groups among the residents. It has thus been necessary to classify the per capita consumption figures accordingly. Nairobi West, Madaraka and Kahawa West were chosen to represent roughly high, medium and low income housing estates respectively for the purposes of this study. A summary of the results is shown below.

Location	Per capita consumption 1/cap/day			Peak factors		Minimum factors	
	measured	design 1983	other studies	measured	design 1983	measured	design 1983
Nairobi West (high income)	120	273	210	2,53	2,00	0,23	0,3
Madaraka (medium income)	115	136	115	2,23	1,75	0,31	0,3
Kahawa West (low income)	20	60	50	-	1,75	-	0,3

Location	Leakage level % of total supply	
	measured	other studies
Nairobi West	20	23
Madaraka	30	32
Kahawa West	-	40

The trend of the per capita consumption values agree for all cases according to classification. However the measured per capita consumption value for Nairobi West is far lower than other for any comparison. The reasons for this are

- either time of measurement was too short, or
- Nairobi West Estate does not represent exactly the high income class; it may be a lower case of the class, or
- the extent of measurement e.g. the number of locations considered in the measurement.

There is a good agreement for the case of medium income group represented by Madaraka. It can be considered that the medium class per capita consumption figure would be an average of the values in the table - 120 l/cap/day - with confidence. The main reason for the low figure for Kahawa West is the system reliability. A lot of water is lost before reaching the consumer. Upto 40 % was realised.

The peak factors were found also higher than the available design ones. This can be attributed to the time of measurement and also the extent of measurement. These figures could be considered together with others from other areas to produce such an average figure as the design values.

Internationally, the per capita values especially that belonging to the medium income class compare well with ones from other cities. For example

Port Said, Egypt	127 l/cap/day
Camiri, Bolivia	137 l/cap/day
Male, Maledives	40 - 100 l/cap/day

Hence the method of measurement, considering the accuracy, is justified.

The factors affecting the domestic water consumption are many. The most important ones are housing and income. In the low density areas, households not only have more water-using fixtures but also have a lower occupancy. Garden watering and car washing are also very common. Hence the per capita consumption is high. In the high density areas, some households have few water outlets, even others share common standpipes. Housing occupancy is high. The per capita consumption is thus low. Hence there is a need to classify the domestic water usage according to housing types.

Besides the general correct belief that income affects the water consumption, there are no data to indicate by how much it does so in Nairobi. With every revision of the water tariff structure to increase prices there has been a lot of complaints of high water prices. Whether the consumers reduce their use or just delay the payment of their bills, is subject to another study. Cross-examination of income information obtained by the questionnaire found it unreliable. Most people were reluctant to divulge correct information on their incomes. As such it is regarded as true that housing classification follows closely the income classes.

Higher peak factors are expected in the high income areas than in medium or low income areas because of the availability of more water-using fixtures and the probability that they are used simultaneously. This is supported by the values 2,53 and 2,23 obtained for Nairobi West and Madaraka respectively. However, they are higher than the design values used by the NCC of 2,00 and 1,75 for similar areas.

The effect of supply pressure is considered in terms of excessive pressure which causes pipe bursts and hence leakages and low pressures causing shortages. Kahawa West Estate is under excessive pressure although it is a relatively new estate and the high supply pressure raises the leakage level to about 40 %. The design criteria requires the minimum pressure head at times of peak demand to be 60 ft (18,4 m) and the maximum static pressure to be 300 ft (91,3 m). Consumers are generally conscious of water conservation. This study found that they were quick to repair a leakage if it occurred in their premises. They also reported a leakage outside their premises if it affected their water supply. But the time taken before such a leak is repaired by the NCC is very long. The consumers were also keen to note any change in the bill amount. In most cases they felt that the amount on the bill was guesswork by meter readers. The billing process and data inputting into the computer were also suspected. This has resulted in the loss of confidence in the water undertaking by the consumers in Nairobi.

All in all the values obtained during this study are suitable only for comparison. The time of measurement and the area of survey - three locations out of about forty - cannot qualify them for design or projection purposes. But they form the basis of a wider survey which could be carried out by the Water and Sewerage Department as a routine water management work.

8 RECOMMENDATIONS

1. Extensive and prolonged similar investigations into domestic water consumption should be done to verify or improve design values under use.

2. A programme should be worked out to test, repair and replace meters periodically and embracing all areas of Nairobi to eliminate the inaccuracies prevalent in metering practices. This would be the responsibility of a unit set within the operations and maintenance section. If organisation problems are anticipated - as the case usually is - a contractor could be hired for such purposes. The same would also apply for planned reduction in unaccounted for water, of which leakages form the bulk.

3. Consumer confidence should be boosted by the following methods:

   a) repairing leakages as soon as they are reported,
   b) improving the billing process to eliminate complaints of unrealistic bills. If guess-work has to be used, due to the inaccessibility of meters, for example, then a true household or per capita consumption figure has to be sought. Hence there is a need to expand the study.

   If the foregoing is achieved the consumers would respond probably more positively to any campaign for water conservation in the city.

4. The method of obtaining more reliable household water consumption should be modified such that different water uses and the frequency of use are studied within the household.

5. A study to evaluate the effect of price on water consumption for Nairobi should be done. The consumer should be enlightened on the works done by Water Department, the costs involved in construction, operation and maintenance. The revenue realised, the advantages of water conservation and how each consumer could benefit from such conservation. This would lessen the adverse impact whenever water charges are raised by the NCC.

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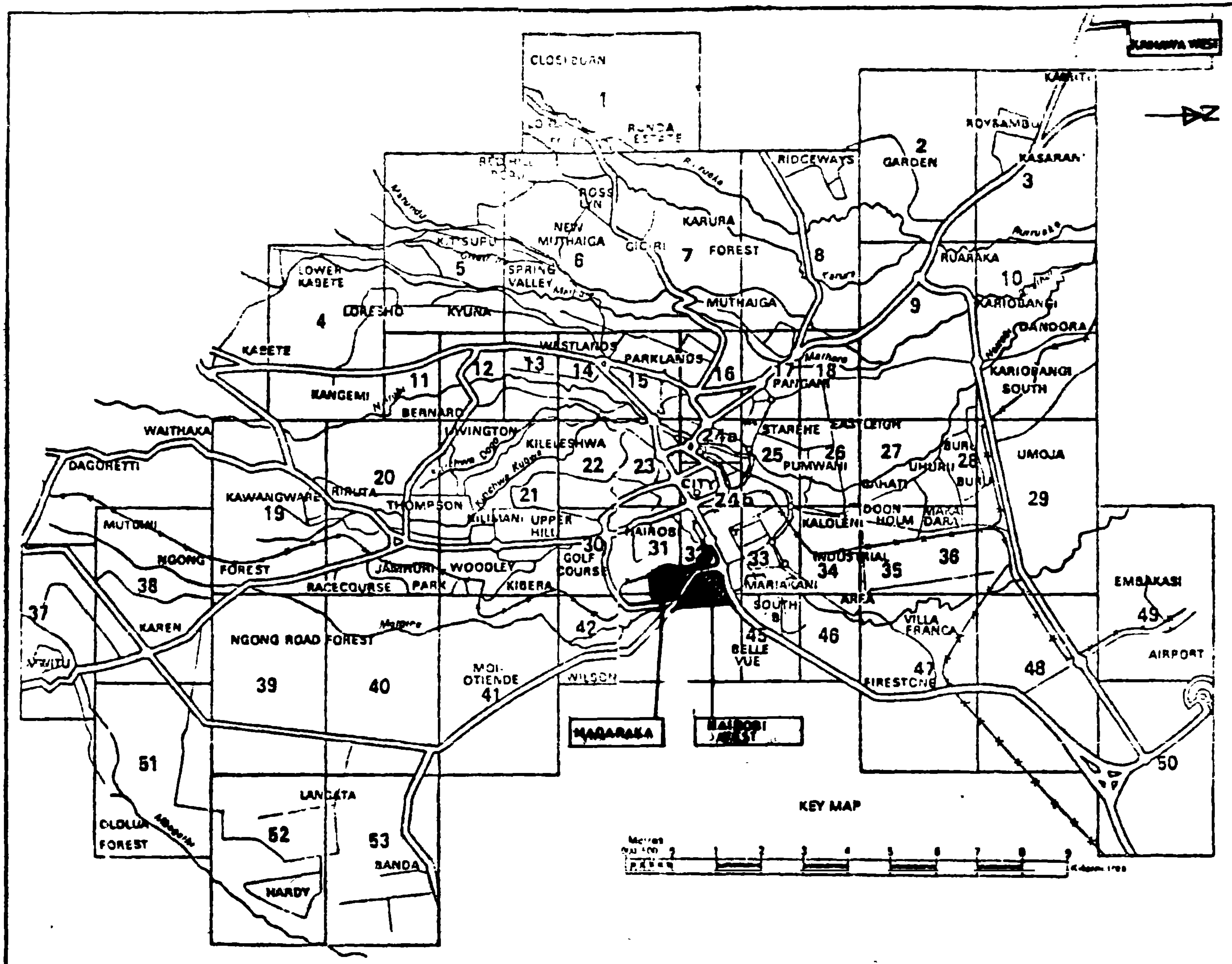
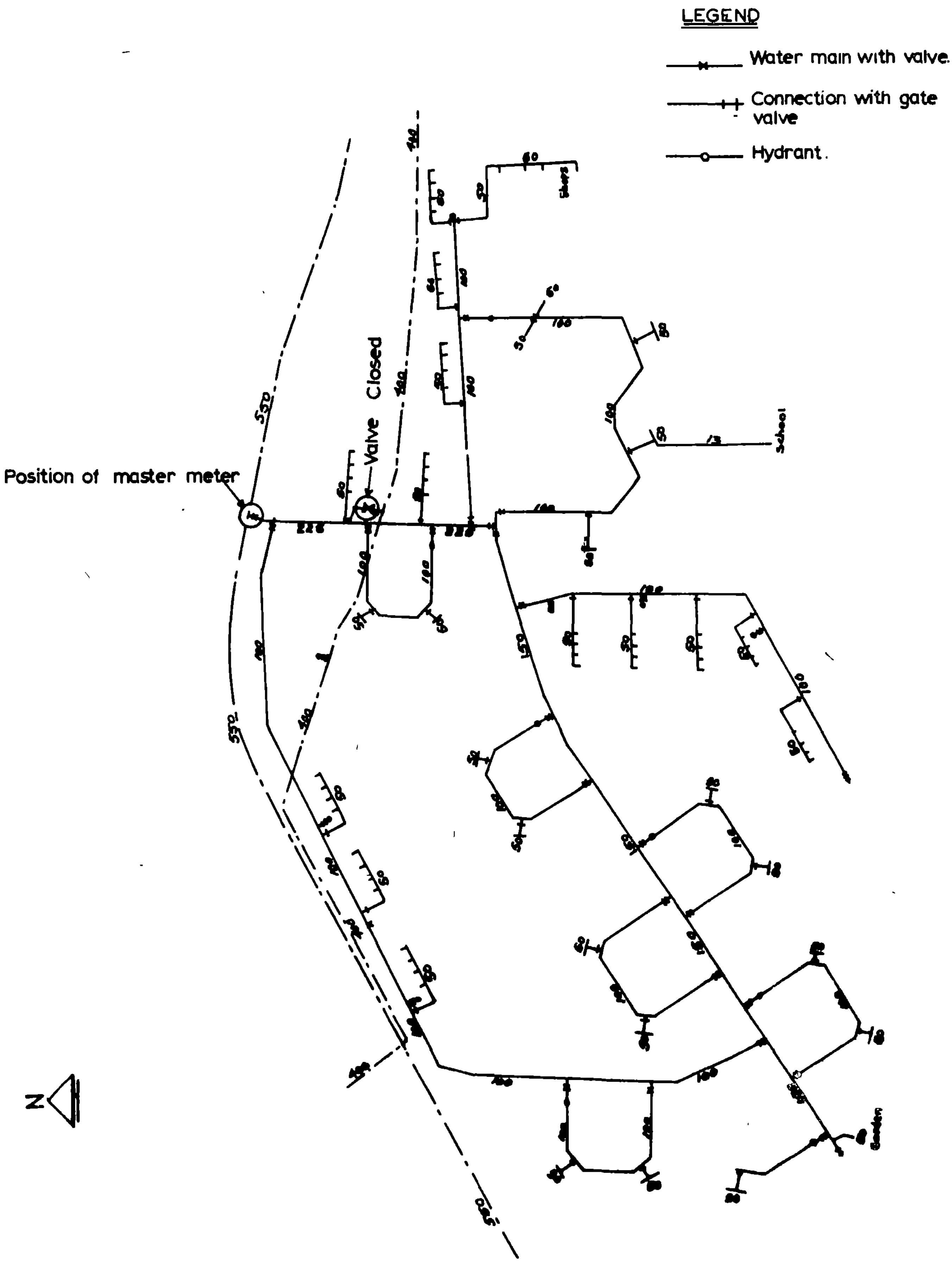
APPENDIX 1

LOCATION OF STUDY AREAS

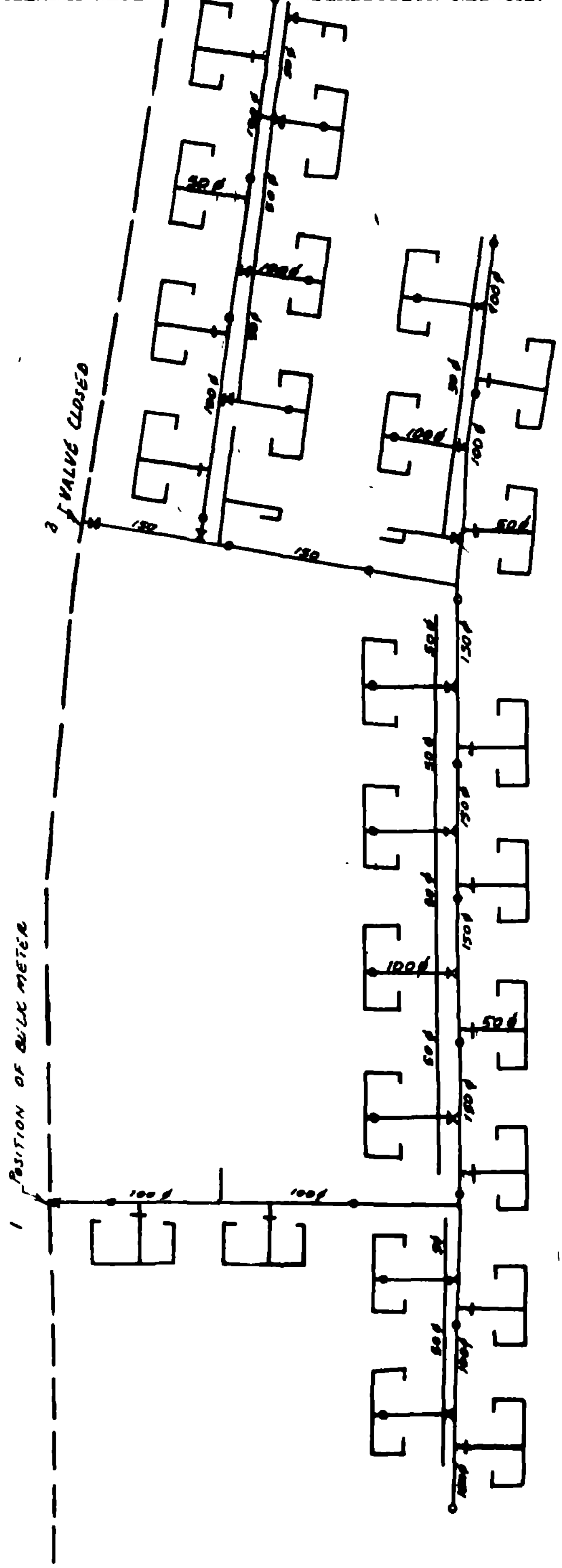


MADARAKA ESTATE - WATER DISTRIBUTION NETWORK APPENDIX 2



KAHAWA WEST - WATER DISTRIBUTION NETWORK

APPENDIX 3



LEGEND

- CONNECTION WITH GATE VALVE
- FIRE HYDRANT
- CONNECTION WITH VALVE

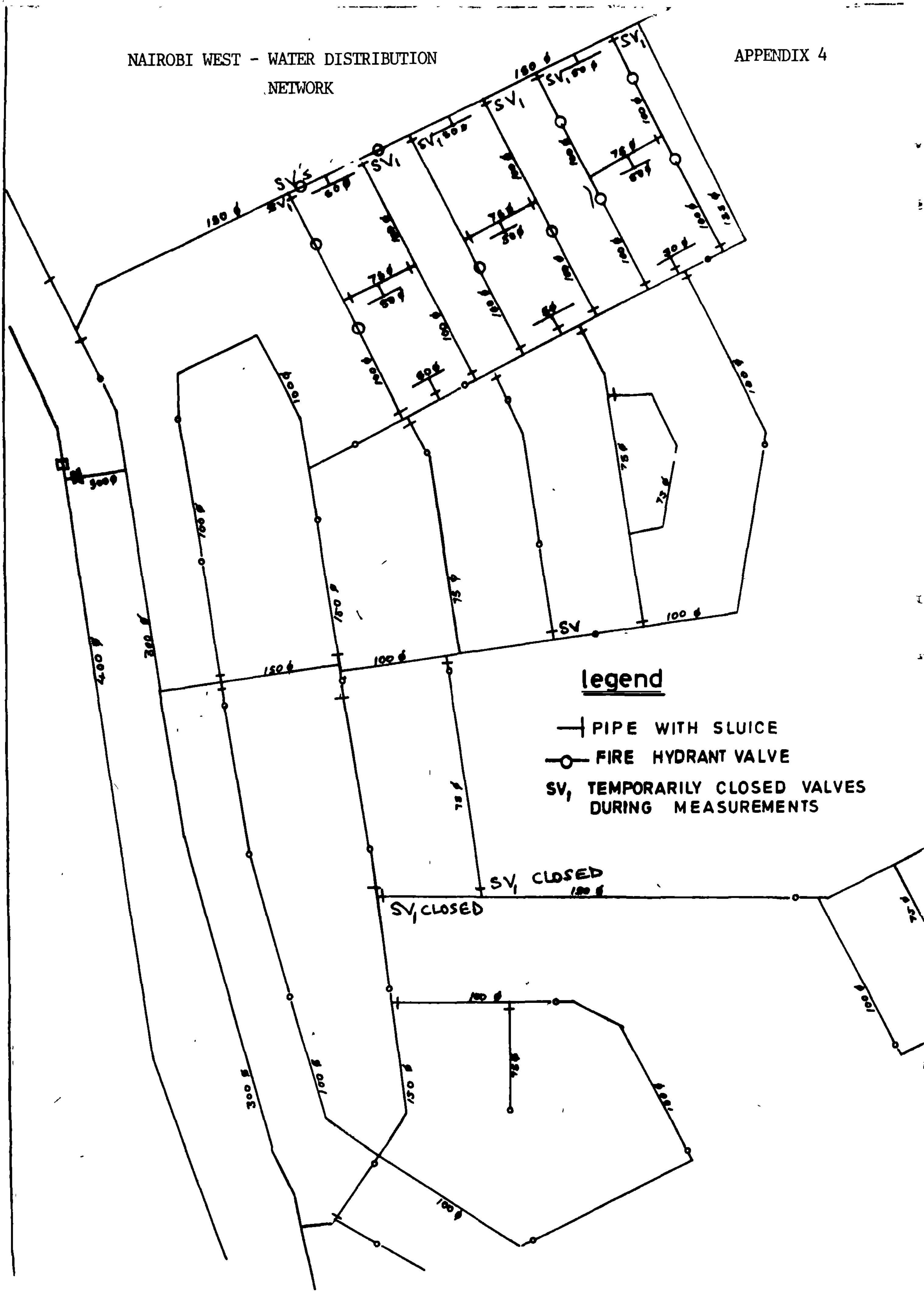
NOTE

VALVE 2 IS PERMANENTLY CLOSED

VALVE 1 IS TEMPORARY CLOSED WHILE READING CONSUMERS METER

NAIROBI WEST - WATER DISTRIBUTION NETWORK

APPENDIX 4



HOUSEHOLD INTERVIEW

This questionnaire is part of a study aimed at improving your water supply problems. Be assured that your answers will be confidential.

Estate ______________________

House No ______________________

Date ______________________

A/C No ______________________

A. Respondent (circle where applicable)

	Profession	Age
A1 Male (Head of household)	______________	______
A2 Female (Head of household)	______________	______
A3 Spouse	______________	______
A4 Other	______________	______

B. Information on household

B1 How many people live in this house?

Permanently No ______________

Temporarily No ______________

B2 How many are working? No ______________

B3 How many are school-going? No ______________

B4 How many are aged 14 years or less? No ______________

B5 How many have lived continuously since July 1984? No ______________

C. Information on house and water consumption (tick where applicable)

C1 Do you get your water from i) common tap ____________

ii) own metered supply ____________

C2 How many water outlets do you have in your house if own metered supply?

inside No __________

outside No __________

C3 What has been your normal range of water bill amount?

______________ to ______________ per month

C4 Do you feel the meter readings to your house have been correct?

Yes or No

D. Information on income

D1 Do you feel that the bill amount if correct is within your financial ability? ____________________

D2 Regular monthly cash income for all household residents

Ksh 0 - 1000 ____
1000 - 2000 ____
2000 - 3000 ____
over 3000 ____

D3 House rent paid Ksh ______________

E. Information on water use and conservation awareness

E1 What do you intend to do with your water in view of the increased prices (tick)

i) Increase usage as I need it ______
ii) Decrease usage as necessary ______ by ______________________

E2 What do you do when there is a leakage

i) before the meter ______________________________________
ii) after the meter towards your house ______________________________

____

F. Information on system reliability

F1 How often do you experience water shortage __________________ in a month

F2 In times of normal supply do you think the supply quantity and pressure are sufficient for your needs? _______________

F3 Does the water bill reflect the amount of water you actually use? _________

G. Consumers' problems

G1 What problems are associated with your water supply?

____
____
____
____

RESULTS OF THE QUESTIONNAIRE

1. Population

Range of occupancy (persons)	Number of dwellings		
	Madaraka	Nairobi West	Kahawa West
1 - 3	42	50	18
4 - 6	65	75	30
7 - 9	58	68	8
10 - 12	20	20	-
over 12	-	10	-
Total	185	223	56
Number of questionnaires delivered	200	250	60

2. Income information

Monthly income (KES)		Number of dwellings		
		Madaraka	Nairobi West	Kahawa West
0 - 1000		4	2	5
1000 - 2000		16	-	23
2000 - 3000		40	20	15
over 3000		75	60	-
Average rent (KES)		1000	2500	1000
Water bill amount within financial ability	Yes	40	56	5
	No	95	26	38

3. Conservation awareness (Leakage control)

Action taken if		Number of dwellings	
	Madaraka	Nairobi West	Kahawa West
leakage is before meter → reporting	175	194	50
→ repairing	-	-	-
leakage is after meter → reporting	175	125	50
→ repairing	-	69	-

4. Consumer problems

Nature of complaint		Number of dwellings reporting	
	Madaraka	Nairobi West	Kahawa West
Delay in repairing leakages	130	5	-
Incorrect bills	124	15	-
Frequent water shortages	20	10	47

NEW WATER TARIFF STRUCTURE EFFECTIVE FROM OCTOBER 1982 BILLING

1. Consumption range	New tariff
0 - 9000 litres	KES 3,08 per 1000 litres or
0 - 2000 gallons	KES 14,00 per 1000 gallons
9001 - 18000 litres	KES 3,87 per 1000 litres or
2001 - 4000 gallons	KES 17,62 per 1000 gallons
2. Water kiosks	
Whole consumption	KES 1,32 per 1000 litres or
	KES 6,00 per 1000 gallons
3. Sewerage tariff	
Whole consumption	KES 1,90 per 1000 litres or
	KES 8,55 per 1000 gallons
4. Meter rents	
a) size ½ " or 1,27 cm	KES 4,00 per month
b) larger than ½ " or 1,27 cm	KES 6,00 per month
c) " " ¼ " or 1,905 cm	KES 8,00 per month
d) " " 1 " or 2,54 cm	KES 16,00 per month
e) " " 1½ " or 3,81 cm	KES 22,00 per month
f) " " 2 " or 5,08 cm	KES 40,00 per month
g) " " 4 " or 10,16 cm	KES 70,00 per month
h) " " 6 " or 15,24 cm	rent by agreement
5. Other fees and charges	
a) reconnection fee	KES 60,oo
b) special reading	KES 20,00
c) sale of sludge	KES 30,00 per m³
d) sewerage connection charge	KES 500,00 per connection
e) reconnection from the main	KES 120,00
6. Minimum charge per month	
a) water	KES 14,00
b) sewer	KES 8,55
c) 1 dustbin	KES 10,00
d) ½ " meter rent	KES 4,00
	36,55

Date: 1982 October

General Manager
Water and Sewerage Department
Nairobi City Council

NEW WATER TARIFF STRUCTURE EFFECTIVE FROM APRIL 1985 BILLING

1. Consumption range	New tariff
0 - 9000 litres	KES 3,55 per 1000 litres
0 - 2000 gallons	KES 16,10 per 1000 gallons
9001 - 18000 litres	KES 5,00 per 1000 litres
2001 - 4000 gallons	KES 21,60 per 1000 gallons
18001 - 30000 litres	KES 6,00 per 1000 litres
4001 - 6666 gallons	KES 27,20 per 1000 gallons
over 30000 litres	KES 6,50 per 1000 litres
over 6666 gallons	KES 29,25 per 1000 gallons

2. Registered water kiosks (no increase)

Whole consumption	KES 1,32 per 1000 litres or
	KES 6,00 per 1000 gallons

3. Sewerage tariff

Whole consumption	KES 2,65 per 1000 litres or
	KES 12,00 per 1000 gallons

4. Minimum charge per month

a) water	KES 16,10
b) sewer	KES 12,00
c) 1 dustbin	KES 10,00
d) ½ " meter rent	KES 6,00
	44,10

5. Meter rents

Size ½ " or 1,27 cm	KES 6,00 per month
Larger than ½ " or 1,27 cm	KES 9,00 per month
" " ¾ " or 1,95 cm	KES 16,00 per month
" " 1 " or 2,54 cm	KES 32,00 per month
" " 1½ " or 3,01 cm	KES 44,00 per month
" " 2 " or 5,08 cm	KES 80,00 per month
" " 4 " or 10,16 cm	KES 140,00 per month
" " 6 " or 15,24 cm	by agreement

6. Deposits

Category	Deposit
a) Eastlands Commission Houses	KES 140,00
b) Domestic houses other than Eastlands	KES 300,00
c) Water kiosks	KES 500,00
d) Commercial premises	KES 1100,00
e) Industrial premises	KES 4200,00

7. Other fees and charges

a) reconnection fee	KES 60,00
b) special reading	KES 20,00
c) sale of sludge	KES 50,00 per m^3
d) sewer connection charges	KES 750,00 per connection

General Manager
Water and Sewerage Department
Nairobi City Commission

TAMPEREEN TEKNILLINEN KORKEAKOULU
VESITEKNIIKKA
JULKAISUSARJA B

TAMPERE UNIVERSITY OF TECHNOLOGY
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