INFLUENCING WATER CONSUMPTION AT

SOUTH STAFFORDSHIRE WATER PLC

A DISAGGREGATED BEHAVIOURAL ANALYSIS OF

CONTRIBUTORY FACTORS

PAUL ANTHONY LE-PROVOST CAPENER

DOCTOR OF PHILOSOPHY

THE UNIVERSITY OF ASTON IN BIRMINGHAM

SEPTEMBER 1992

TEXT BOUND INTO

THE SPINE

THESIS SUMMARY

THE UNIVERSITY OF ASTON IN BIRMINGHAM

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This research identifies factors which influence the consumption of potable water supplied to customers property . A complete spectrum of the customer base is examined including household, commercial and industrial properties. The research considers information from around the world, particularly demand management and tariff related projects from North America.

A device termed the Flow Moderator was developed and proven, with extensive trials, to conserve water at a rate equivalent to 40 litres/property/day whilst maintaining standards-of-service considerably in excess of Regulatory requirements. A detailed appraisal of the Moderator underlines the costs and benefits available to the industry through deliberate application of even mild demand management. More radically the concept of a charging policy utilising the Moderator is developed and appraised. Advantages include the lower costs of conventional fixed-price charging systems coupled with the conservation and equitability aspects associated with metering.

Explanatory models were developed linking consumption to a range of variables for customers of all classes. In particular the models demonstrated that households served by a communal water service-pipe (known in the UK as a shared supply) are subject to associated restrictions equivalent to -180 litres/property/day.

The research confirmed that occupancy levels were a significant predictive element for household, commercial and industrial customers. The occurrence of on-property leakage was also demonstrated to be a significant factor recorded as an event which offers considerable scope for demand management in its own right.

KEY WORDS:- Demand Management, Flow Moderator, Standards of Service, Leakage.

DEDICATION

In memory of my father

Barrie Charles Le-Provost Capener

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

This thesis is based on research undertaken within South Staffordshire Water PLC. For the seven year period commencing October 1985. The work is a product of the authors initiative with the support and sponsorship of South Staffordshire Water PLC and the academic supervision of Aston Business School.

1.1 AIMS OF THE RESEARCH

The aim of the research was to identify factors affecting or influencing consumption of water on customer property. Surveys undertaken, particularly on households, show large variation without necessarily conforming to expected trends. For example it would be reasonable to assume that single person households consume less water than family residences. Research tends to support this theory but, in practice, the relationship can be seen to diverge. Highest order consumption can be recorded at single person houses and vice-versa. Such an example indicates other factors can significantly influence consumption.

The purpose in undertaking this investigation was to improve base knowledge, which is implicitly required to undertake realistic water audits and forecasting, and to provide an assessment of targets for the concept of demand management.

Three approaches were developed as tools to prosecute this research and as such represent additions to the literature on factors influencing water consumption particularly in the UK. The three areas of research overlap but are fundamentally described as:-

1. A contingent valuation methodology applied, using formal interview and questionnaire approach, to "metered" customers.

2. An assessment of social and physical factors influencing household consumption and

3. The application and assessment of an imposed physical demand management device applied to households.

One half of daily water production at South Staffordshire Water PLC is consumed by unmetered households and one quarter by metered customers of all classes. Thus, when combined, the population considered by this research accounts for three-quarters of daily supplies.

Experiences outside of the UK, particularly from North America, proved instrumental to the formulation of methodology and analysis. However climate, consumption, economics and social attitudes are considered significantly different between, for example, England and America to de-value direct comparison of both absolute values and relationships.

Original specifications for the research were essentially practical and the results must therefore also be considered for their practical merit. That is not only as an original insight to consumption influencers or determinates but also as a methodology for application elsewhere.

1.2 THE UK WATER INDUSTRY

The UK water industry provides services to households, agriculture, industry, commerce, other public utilities, local and national government bodies. In short to the complete spectrum of U.K. consumers.

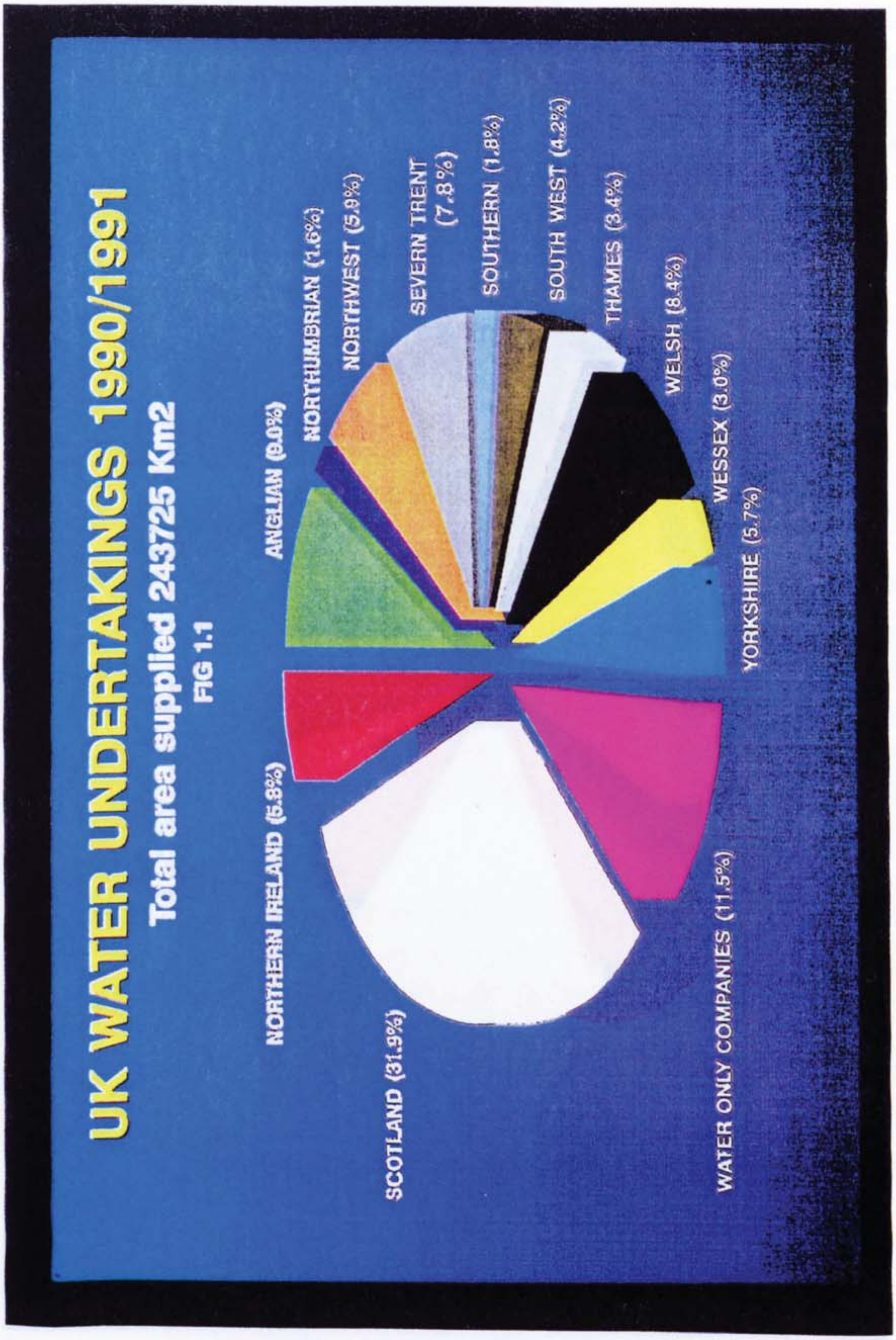
An extensive range of services are offered including piped water supplies, which form the focus for this research. The Centre for the Study of Regulated Industries (1990), divided Water Services into the five following classifications:-

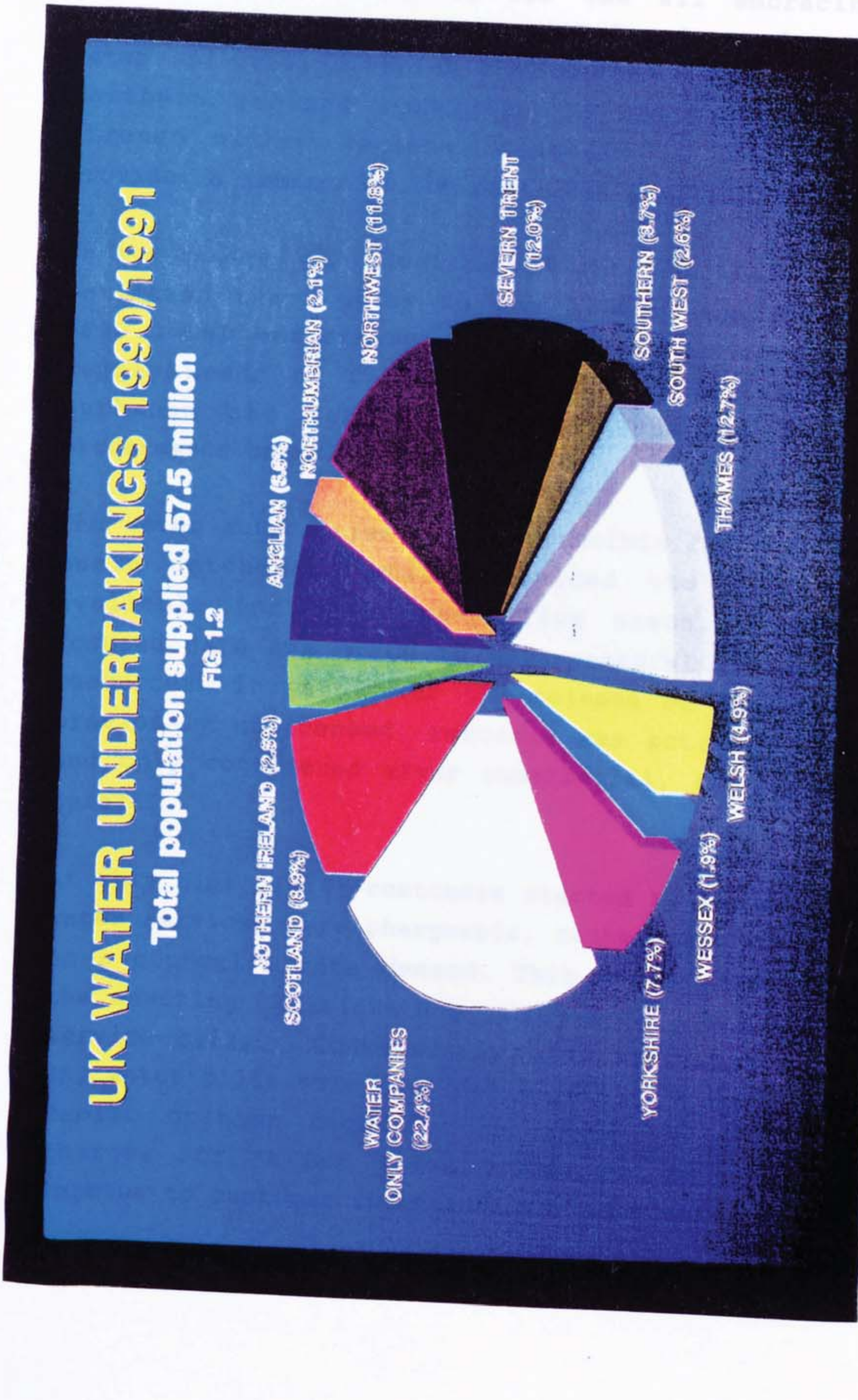
1. Water Resources
2. Water Supply
3. Sewerage Services
4. Effluent Discharge and Environmental Services
5. Flood Defence and Land Drainage

This research concentrates upon the specific element of Water Supply, being the end-of-chain delivery, upon demand, of water to customers at their properties.

The UK water industry probably offers the most comprehensive range of services in the world. The Centre for the Study of Regulated Industries (1990/91)pp 9, shows that some 99.6% of the 57.3 million UK residents receive direct water supplies and 97.2% are connected to a main sewerage system. Substantial direct use is also made of rivers, lakes and boreholes etc. to augment supplies to industry and agriculture. Tables 1.1, 1.2 and Figures 1.1 and 1.2 provide details of population, supply area and service infrastructure for England and Wales.

Prior to 1974, water services were the responsibility of either quasi government organisations, in the general form of District Councils, or a handful of long standing private, statutory, companies such as South Staffordshire Water. From 1974 Ten Regional Water Authorities were created to cover water service responsibilities in England and Wales.


UK WATER UNDERTAKINGS 1990/1991
Total area supplied 243725 Km2
FIG 1.1
NORTHERN IRELAND (5.8%)
ANGLIAN (9.0%)
NORTHUMBRIAN (1.6%)
NORTHWEST (5.9%)
SCOTLAND (31.9%)
SEVERN TRENT (7.8%)
SOUTHERN (1.8%)
SOUTH WEST (4.2%)
THAMES (3.4%)
WELSH (8.4%)
WESSEX (3.0%)
WATER ONLY COMPANIES (11.5%)
YORKSHIRE (5.7%)



UK WATER UNDERTAKINGS 1990/1991
Total population supplied 57.5 million
FIG 1.2
NOTHERN IRELAND (2.8%)
SCOTLAND (8.9%)
ANGLIAN (5.6%)
NORTHUMBRIAN (2.1%)
NORTHWEST (11.8%)
SEVERN TRENT (12.0%)
SOUTHERN (3.7%)
SOUTH WEST (2.6%)
THAMES (12.7%)
WELSH (4.9%)
WESSEX (1.9%)
YORKSHIRE (7.7%)
WATER ONLY COMPANIES (22.4%)

Twenty eight statutory water companies, predating the reorganisation, remained in existence supplying water only and operating as agents for the all embracing water authorities. In total there was therefore, from 1974, 38 water utilities covering England and Wales. Scotland and Northern Ireland continued to administer operations through either Regional Councils or DoE. Figure 1.3 provides a summary of the post 1974 position.

In its summary on privatisation the Government (HMG, 1986) estimated that, prior to the 1974 reorganisation, some 1600 local undertakings had evolved to meet the water supply needs of England and Wales. This is echoed by Buchanan and Verry (1989) who mention around 1400 predecessor boards and authorities.

The water authorities were responsible for complete river basin catchments which provided the water resource available for their respective areas. As such, more focused care was given to environmental issues affecting resources. In particular the release of additional, i.e. previously unlicensed, resource was actively discouraged and only considered after substantial, and often public, debate.

At this time (1974) customers started to become aware that water services were chargeable, rather than being "hidden" on a council's rate demand. This was a direct result of the enacting legislation's requirement for separate water service bills. Consequently, for the first time in the UK, water bills were provided directly to customers homes. Public opinion began to be heard in protest against charges for "a God given resource". This in turn gave impetus to customer intentions to "save water".

Then and now, most UK customers, particularly households, pay for water on an arbitrary basis. Dependence being modelled around taxation in the form of domestic rateable value (R.V). This method provides an approximation between property value, potential for water use, and hence the size of water bill. Industrial customers generally pay for potable supplies by volume, through water meters. The same meter provides a basis for effluent disposal charges.

Commercial customers continue to fall into either category, some metered some not. A national mandatory metering scheme, for commercial customers, has been in existence, since April 1983, but many thousands still remain on open (un-metered) supplies. Generally, all new commercial establishments are metered and all existing unmetered commercial properties are required to be metered by the year 2000.

Household customers retain the option to request installation of a meter through the Meter Options Scheme. Thus a safety valve has been provided for aggrieved customers. In practice only a minority of household customers have elected to pay by volume. In general, therefore, household metered customers tend to be those who recognised that savings could be achieved through water metering. As such, traditional household metered customers exhibit a pronounced bias towards either low consumption, high R.V or some combination.

Recently, November 1989, the Industry entered a new phase: The Authorities were sold into the private sector. The enabling legislation, the Water Act 1989 also established the Secretaries of State for the Environment and Wales, the Director General of the Office of Water Services (OFWAT) and the National Rivers Authority (NRA) as the principal regulators of the industry.

The responsibilities of the Secretaries of State include regulation of drinking water, those of the Director General include economic regulation and those of the NRA include the management of water resources.

The establishment of the Director General for Water Services provided parity with the regulatory controls of other utilities. The primary duty of the Secretaries of State and the Director General, in this respect, are to ensure water, and sewerage, functions are properly undertaken and financed. Subject to these conditions being satisfied there is a secondary requirement to stimulate responsiveness to the customer through "yardstick" performance comparison and the establishment of direct competition.

The 1989 Water Act was also the instrument which removed the traditional Rateable Value Charging mechanism as an option. This mechanism now only remains in place, as a transitional arrangement, for existing customers until the year 2000.

Alternative charging frameworks must therefore be investigated, confirmed and set in place before this deadline. It is likely that several options will be available for customers, at the utilities discretion. These may be designed to reduce consumption or to facilitate rapid and low cost charging mechanisms. A consequence of the changes has been the widespread adoption of metering for most new customers throughout the country. Whilst this has created a large customer group, for whom detailed consumption records exist, this sample is biased in favour of "new supplies" . These do not, however, necessarily reflect patterns of consumption for older and perhaps less well provided properties.

The Water Act 1989 re-focused responsibility for water charges, for council tenants, from Local Authorities directly to water utilities. Previously a single invoice, for all council owned and tenanted property, was served to the respective Town Hall. Each separate Authority was then responsible for paying the bill and recovering monies from its own tenants. This was normally achieved by including water service charges with periodically collected property rentals.

Subsequently this has created significant awareness and substantial short term payment defaults for this specific group of households. In turn this has created substantial national media interest both in the revenue recovery process and, more generally, in the water industry.

Socially this fact mirrors the national reorganisation changes, of 1974, in that another large sector was suddenly faced with separated direct billing and is reacting negatively to change. The reaction is seen as a response to the fact of the charge and not the size of the bill.

Measures currently before industry appear to be directing future charging policies towards metering. The rights and wrongs of this specific "debate" are not at issue within the bounds of this research. However aspects of metering relating to influencing on-property consumption are examined and can be considered as essential to the context.

In extending the Governments philosophy of "The Citizen's Charter" to the water industry two new elements have been injected into the traditional sphere of waterworks practice.

Introduced with the privatisation legislation of 1989, were Licences granting water utilities the right to operate. Under condition J of the Licence, companies are required to provide information on Levels of Service. These are designed to protect customer rights and expectations in the following categories:-

- DG1. Raw Water Availability.
- DG2. Pressure of Mains Water.
- DG3. Interruptions to Water Supplies.
- DG4. Water Usage Restrictions.
- DG5. Flooding From Sewers.
- DG6. Response to Billing Queries.
- DG7. Response to Written Complaints.

Levels of Service Indicators relevant to the research are discussed in the main text of the thesis.

The second element refers to the Governments Competition and Utilities Act 1992. Designed to promote the potential for large customers to obtain competitive supplies. The legislation provides a mechanism which can permit existing water companies to connect to customers beyond traditional boundaries. The possibilities of new players coming into existence through "Inset Agreements" is also encompassed.

With reference to competitive bids, for large customers, current thresholds for qualifying are; those customers consuming in excess of 250 Ml/year. In this respect aspects of the research, identifying factors which assist in predicting consumption of major trade customers, may prove of secondary benefit. Water utilities adopting an aggressive marketing approach may be better able to predict which customers, beyond limits of supply, qualify for competitive bids.

1.3 SOUTH STAFFORDSHIRE WATER PLC

The origin of the UK water industry had its roots in the mid 19th Century when, enteric, water borne disease became epidemic. In Staffordshire, records show that the massive death rate due to cholera, in the 1800's, was so overwhelming that authorities were forced to provide remote overspill burial grounds. Elwell (1979) reported that the Government Sanitary Inspector, in 1810, wrote that "in no part of England and Wales is the work of human extermination carried out so successfully as in the district round Dudley".

There was an increasing number of industrial enterprises, a rapidly expanding population and excessive pollution which all contributed to human casualties. However the report concluded that "the biggest single cause, of human extermination, was the almost total lack of a constant and plentiful supply of pure water".

Feeny (1880) described the area; "in nearly all places the supply available for household purposes was woefully deficient". Inhabitants were reduced to drink the foulest contents of canals and coal pits. "The people gladly bought water drained from pits and engines at a cost of from 6 to 10 shillings per week. At Tipton almost the entire population, of 21000, were dependant for water on the canal from which the local beer was also brewed".

The consequences were inevitable. Elwell (1979) stated that " not only were there frequent out-breaks of cholera but typhus, opthalmia and every sort of fever were rife. Moreover when the only drinkable liquid was alcoholic the risk of addiction must have been abnormally high".

The public were naturaly concerned but at that time generally unable to insist upon, or even recognise, suitable solutions.

Apart from public personal loss of life, industrialists felt the effects upon their respective businesses. Whilst labour may have been cheap the loss of reliable and skilled operatives was, at the very least, inconvenient. Further it was being recognised that the provision of welfare for workers, and their families, induced some loyalty and forged ties to employers.

Water was also being used in ever greater quantities for commercial and industrial purposes. Locally won supplies were available but becoming scarce and polluted, a need for more convenient and reliable supplies was evolving.

The Dudley Waterworks had been established in 1834 and the Wolverhampton Waterworks in 1845. Plans to extend and improve the supply of water rested with these two companies. After two abortive attempts from the rival companies a collaborative effort finally received Royal Assent on 4th August 1853 and South Staffordshire Waterworks Company came into existence.

The late John Robinson McClean is generally credited as the founder of the Company. McClean had also constructed and become the Lessee of the South Staffordshire Railway. Using this convenient land route, engineers provided the distribution system taking water from Lichfield through 22" cast iron pipes some 15 miles to the industrial heartlands of Walsall, West Bromwich, Dudley and Wolverhampton. Elwell (1979) prefers to credit Samuel Holden Blackwell as the founder of the Company. Pointing to his substantial diplomatic skills in merging rival plans and obtaining the Act of Parliament

The Company was originally formed to deliver bulk supplies of water only, leaving retail distribution to existing water supply companies and particularly Boards of Health. In practice, however, Local Boards of Health showed a marked resistance to provide and develop local distribution systems, preferring to wait for others to carry the investment and risk.

In 1860, only some 5685 properties were connected to the South Staffordsire Waterworks system.

The 1866 Act of Parliament increased the area of supply to 250 square miles covering an estimated 400000 population. The majority of customers, however, either did not want or could not afford piped water. In 1878, at Smethwick, 928 householders out of 948 visited considered themselves sufficiently supplied from existing, non-piped, means.

In 1869 it was reported (Van Leerzem and Williams, 1990) that "20000 houses were supplied". Bulk supplies to Tamworth were completed by 1881. At an 1873 meeting, Walsall Town Council heard that "a quarter of inhabitants were totally unsupplied, one eighth imperfectly supplied and many partially supplied". By 1875 Directors of the Company had taken the view that "it was their positive duty to provide a supply to the many populous places still without water".

Bateman (1876) identified the need for "the provision of twenty gallons per head per day for domestic usage" at a pressure of fifty feet head above street level in Dudley". The Companies then Engineer in Chief, William Vawdrey is reported by Van Leerzam and Williams (1990) as describing the Companies principle mains in 1875 as "A twenty inch main, Lichfield to Brownhills. A six inch main, Brownhills to Chasetown. Twenty inch main, Brownhill to Walsall and Wednesbury. A fourteen inch main, Wood Green to West Bromwich. An eighteen inch main Wednesbury with a twelve inch branch to Tipton and Dudley. A twenty four inch, Wood Green to West Bromwich. A twelve inch to Oldbury, a six inch to Smetwick and a six inch connecting Oldbury to Smethwick. The consumption at this time was five million gallons per day".

By 1878, 30962 services were connected directly to the company system. The average number of houses sharing a supply was three and one quarter with 16 properties to one service recorded as the maximum. Trunk mains totalled eighty one miles in 1882 with one hundred and eighty nine miles of service pipe.

Van Leerzem and Williams (1990) reported that following a precedent set in a case, heard by the House of Lords, Dobbs v Grand Junction Water Company 1883 The Company altered their practices and charged for water on the rate of net annual property value.

By 1893, 81000 services had been laid and connected accounting for some seven million gallons of water per day. Records show that in 1896 the number of connected services had reached 92007, consuming 12 million gallons per day. The limits of the supply area encompassed a population of 565000.

One of many drought periods occurred in 1899 causing consumers to correspond with the Company and local press. Of greater consequence customers were tempted to use unsafe water from wells long since abandoned in favour of Company supplies. Accounts for the year 1903 show that services connected were 117035.

A gross expansion of industrial use occurred as a result of the war effort, supplies for household usage were severely impaired. Large areas experienced supplies being deliberately shut off each day from seven in the morning until seven at night thus ensuring water for munitions and ordnance works.

Subsequent to the armistice, demand was prevented from returning to normal due to severe frost in 1918/1919 causing great wastage, (Van Leerzem and Williams, 1990).

In 1925, 989 miles of main was recorded as supplying 158000 houses and 4200 trade supplies. Special efforts had been made by the Company to reduce water lost through leakage and waste. Thus during the years 1922 to 1927 it was reported (Van Leerzem and Williams, 1990) that "ninety four waste detection meters were installed and thirty additional inspectors engaged as waste detection staff". Anecdotal evidence indicates that ladies undertook some of the duties of waste detection which were considered relatively unstrenuous.

1975 and 1976 saw drought conditions return to the country. Waste detection duties were carried out night and day by many employees. A drought order was obtained under the Drought Act 1976 prohibiting the use of all non-essential supplies. By 1979 daily consumption had risen to 71 million gallons.

Today the Company supplies some 600 square miles (1554 km^2) from Halesowen to Deryshire and Kinver to Burton-upon-Trent. Average quantities of water supplied are 79 million gallons per day (360 Ml/day) through 3384 miles (5446 km) of mains. Topography, varying from 40 to 285 metres above sea level, dictated the development of a complex distribution system with substantial re-pumping and pressure control required to maintain supplies. 1216000 people living in 478000 households are connected to the network together with 30000 metered customers. Charges for water remain as the second lowest in the country.

1.4 ORGANISATION OF THE THESIS

The thesis is organised to reflect the practical progression of the research from conception to conclusion. Split into five parts representing progressive stages, each can be consulted as a self contained element to suit readers requirements. Cross referencing between sections is included to assist with the location of supporting evidence.

1.4.1. PART 1

The thesis commences by Providing an insight into the water industry in general and South Staffordshire Water PLC in particular. The information is presented to set the scene for the research and to underline the reasons and scope for demand management in the UK.

The aims of the research are stated including a brief summary of principle methodology adopted.

Significant findings from an extensive and prolonged literature review are distilled and presented as Chapter 2. The methodology employed to establish and obtain relevant literature is recorded for reference. Details of literature referred to in the thesis are included immediately before the Appendices.

The review focuses upon charging policy and pricing, demand management, water consumption trends and methodologies adopted, for both survey and analysis, elsewhere.

Part 1 is completed with a summary of salient points from the literature review carried forward to shape the research.

1.4.2. PART 2.

Taking account of the review, requirements for research in the field of demand management and consumption variables are identified and developed. Part Two represents the combined influence of the literature review and personal experiences, applied to shape the direction of this research. Variables, potentially influencing consumption, are considered in detail for inclusion in subsequent methodology, if appropriate. This element of the research concludes by stating developed objectives and formulating hypotheses.

1.4.3. PART 3.

Part three progresses the research by presenting the development of a suitable methodology to test the hypotheses, taking account of criteria identified in preceding chapters and particularly the case-studies described in section 2.7. Chapter 5 describes the research undertaken to identify a suitable mechanism to modify household customer consumption, then concludes by developing and testing the device in practice.

Chapter 6 takes the development of the methodology further by considering how to assess the influence of the device (Moderator) upon household consumption. Implicit in the approach is the parallel development of methodology to determine influence exercised by a multiple of other variables. Chapter 7 provides a detailed description of the household sample obtained, by applying derived methodologies, for subsequent analysis.

In a similar manner Chapter 8 develops a methodology for obtaining a sample of metered customers.

1.4.4. PART 4.

Analysis of information obtained for the two groups, identified as household and metered, is presented and analysed in chapters 9 and 10. Chapter 11 presents an appraisal of the "Moderator" device, developed to deliberately influence customer demand. Part 4 concludes with chapter 12 discussing findings and detailing conclusions for all customer groups and recommending additional research to answer identified queries.

The thesis concludes with references and appendices provided to complement the research.

CHAPTER 2

LITERATURE REVIEW

2.0 OBJECTIVE OF THE REVIEW

The literature review was undertaken to enable this research to be placed in context with previous works. It is an integral part of an evolutionary process, taking account of principles and experience reported elsewhere, to influence and ultimately shape the direction taken by the author in adding a relevant contribution to the market place.

The specific objective of the literature review was to identify and examine recent academic works which have progressed measures identifying or influencing on property demand for water.

2.1 SIGNIFICANCE OF TOPICS COVERED

In recent years the U.K. Water Industry has recognised that there are alternatives to the conventional, on-going, development of water resources. This trend has occurred because of a combination of economic, physical, climatic and particularly social constraints including a growing environmental and political awareness of the issues involved.

Away from these shores, similar requirements began to occur, due in part to climatic and cultural differences, more than 30 years ago.

As a result the topic of "water conservation" has received considerable academic and professional exposure, particularly in North America. Many authors have examined and reported on their experiences and literature is extensive.

This review provides a summary of relevant theory and practice. Where multiple text's occur, either the latest or most relevant literature has been described.

2.2 SCOPE OF REVIEW

The research assumes that the requirement for controlling demand can be justified, either per-se or for individual projects. Reference is made to such issues, only to place this work in context. No account is therefore given to either the requirements of 'economic' pricing, to maintain viability of an organisation, or an examination of environmental arguments. In practice these considerations may force political rather than economic or even conservation solutions.

Significant works have been undertaken and reported covering the areas of distribution network conservation, particularly control of system pressure and leakage. Each measure can yield significant water conservation and are rightly being recognised as worthy of equality with conventional water resources management. Both topics are, however, considered to be outside the area covered by this thesis except specific aspects impacting directly with on-property conservation. These are; water savings generated through the repair of on-property leakage and the associated causal reduction of on-property water usage when subject to reduced pressure.

Both the thesis and this review specifically investigate approaches ultimately intended for the control of on-property water consumption.

The research is intended to break new ground, particularly in the UK, by examining variables which can affect household, commercial and industrial water consumption. The review allows comparisons to be made with findings from this research and those reported previously.

A unique aspect of the research concerns the application of an external physical influencing device specific to each property.

Charging policies and practices are considered in detail with respect to their use as a potential demand influencer.

The work is not intended to be purely narrative. It is designed to incorporate a level of applied mathematical rigour likely to be found in the industry.

However this has to be consistent with robust examination of the relationships involved whilst providing the necessary standard to be acceptable for academic research.

Applying this specification, the review was targetted towards contributions from authors who have sought to report an insight to the theoretical and practical aspects of on-property water conservation.

The literature review covers solutions and mechanisms, applied to test solutions, theory and practice of customer behaviour variables. Many aspects of the review are summarised as anecdotal case studies. Limited background information is given where necessary to aid contextual understanding.

The review is divided into the following elements:

2.2.1. CHARGING FOR WATER SERVICES

An examination of historical, international and political constraints and experiences that together have created current UK practice and will shape future direction.

Charging options are identified and briefly commented upon. Detailed examination of relevant issues in this respect are considered by examining the actual effects of each option under the section entitled "Demand Management".

The assessment of price-elasticity for water supplies is examined through the consideration of tariffs and competition. This is particularly applicable to control of demand through fiscal measures and the use of a physical demand restrictor as a basis for charging strategy.

2.2.2. DEMAND MANAGEMENT

A review of demand management theory and practice is undertaken by examining four distinct approaches. The majority of 'point-of-use' conservation measures are taken from North American experiences. The review concludes by presenting combinations of applied measures taken from case-study examples.

2.2.3. COMPONENTS AND TRENDS OF WATER CONSUMPTION

To provide a comparison with U.K. and International water consumption, particularly European and north American, a review of trends is undertaken. This ultimately puts into context the desirable and actual levels of UK consumption.

2.2.4. COMPARISON OF SURVEY AND ANALYSIS METHODOLOGIES

This review provides information on variables considered to influence consumption and provided major assistance in the research design. Reviews of approaches to customer surveys and analysis methodology were also undertaken. A number of case studies are presented as models of conceptual approach and analysis. Results of analytical and empirical forecasting are detailed for later comparison.

The implications of the literature review are considered in Chapter 3, detailing research design.

2.3 METHOD OF LITERATURE REVIEW

The literature search which formed the basis of the review in this chapter was undertaken over seven years. Many of the articles collected either became irrelevant to the research, as its direction became focused, or superseded by later literature. This is considered to be a natural and healthy element of a long term research project. Examination of the relevant literature collected during the first, and formative, year, Capener (1986), shows that almost no works, from this early period, have been included in the final submission.

Initially the literature search was undertaken using manual methods at local public and university libraries.

A substantial amount of documentation was also generated either from personnel knowledge of the subject or via the Water Research Centre's libraries at Swindon and Medmenham.

Reference to the; Social Science Citation Index, Index to Thesis, Current Contents and Index to Scientific and Technical Proceedings provided a wealth of literature. Articles so derived assisted particularly in providing information on the research from a 'social sciences ' rather than engineering perspectives.

As the research progressed it became apparent that the most relevant articles were available from the WRc, conference proceedings and current journals, which had been identified during the initial search. Therefore abstract updates, post 1988, were concentrated in these directions. A small number of articles proved difficult to obtain but in each case the WRc or staff at the British Lending Library were able to assist.

2.4 CHARGING FOR WATER SERVICE

2.4.1 INTRODUCTION

Having established the fundamental requirements for a convenient and safe water supply the review can now be extended. The availability of piped water supplies, with a reliable yield, is taken for granted in most countries. How then are these services charged for? In particular how do the various charging methods influence customers willingness to control, or even think about, their use of water?

This section reviews methods employed to apportion charges for the provision of water services and identifies options under consideration, in the UK, as alternatives to traditional Rateable Value approaches. These, as explained in section 1.2, must be phased out by April 2000.

Evidence on the price-elasticity of demand for water is examined to assist in placing in context customers behavioural reaction to the control of demand for water.

Assessment of the effects of applying charging options to influence consumption are, however, considered separately in section 2.5, Demand Management.

2.4.2 DEVELOPMENT OF CHARGING METHODS

Returning to the origins of the Water Industry, described in Chapter 1, individuals were originally not called upon to pay directly for water services; rather their employers provided a service that suited their own commercial needs (Elwell 1979). It is however certain that costs were recouped using a variety of methods, some relating directly to individuals or commerce and yet others directed towards the community.

In the report on report on Public Utility Charging Policy (Thackray, 1988) examined in detail the argument that water could, in fact, be a free community service. It was recognised that this would save the cost of separate billing and, in principle, ensure availability to all. Operating costs would still, however, have to be met, most probably through community taxation. A free service would "also be likely to be wasted by the careless or unscrupulous, without penalty."

The report considered that an alternative would be to meet all costs from direct charges for services provided. This represents: "an increase in costs due to administration, billing, debt recovery and queries." However it still does not provide a direct incentive for customers to control their demand. This approach is akin to the traditional Rateable Value method which has provided the basic charging mechanism in the UK.

Customers may request water supplies but, if given a choice, would they wish to fund expensive treatment of used water? "It is likely that many customers would be quite happy to just get dirty water away from their premises, perhaps into the river or sea, and leave the environment to deal with it" (Thackray, 1988). In such a scenario the community, by default, would be responsible for paying rather than the individual.

Commonly it is the case that water supply and resource costs are funded as direct charges, by individuals, but that drainage, used water and environmental services are met by the community. In this respect Thackray (1988) commented that: "This may, at best, be through funding works from community taxation or, at worst, by accepting and living with the costs of environmental damage."

The Water Companies of England and Wales are required to recover almost all costs directly from the customer. This is stated as being; "unique in the developed world" (Cranston, 1988). Conversely, in Northern Ireland, almost full recovery through taxation is practised, including household supplies. A mixed solution, somewhere between the two, remains as the most common form of cost recovery throughout the world.

The split between direct apportionment of charges and those levied through community taxation was argued (Cranston, 1989) as: "clearly affecting the bills people pay and, in consequence, their material assessment of service costs."

In setting charging policies, UK and overseas water undertakers attempted to achieve "a wide range of objectives" (Director General, 1991). These were itemised in the "Paying For Water" report as:-

i) Financial
ii) Economic
iii) Equity
iv) Public Health
v) Environmental Protection
vi) Economic Development and Employment Generation
vii) Administrative simplicity.

The criteria selected to determine charging policy depends upon "the importance attached to each of these objectives". The report also commented that: "Given this range of objectives it is hardly surprising that there is no one charging system that commands universal approval."

In those countries with strong British links "the most frequently used base for annual water fees was property values." The logic supporting this approach was that "the value of a family's property was a good proxy for its wealth." Alternatives were "chosen because it was thought that they provided a surrogate for consumption".

In particular the report (Director General, 1991) commented that:-

> "The key disadvantage of all flat rate payment schemes is that consumers pay the same irrespective of their actual consumption and irrespective of the costs of providing them with water services. Once this annual charge is paid, water becomes a free good; customers have no incentive to conserve water and may indeed be extravagant in their use to ensure that they 'get their money's worth'."

It was stated (Thackray ,1988) that, with respect to subsidised water supplies, "Governments tend to subsidise rich and poor alike". The report considered that this would "easily lead to the better placed receiving more by way of subsidy than the poor". Further it was stated that "partial charging approaches give considerable competitive advantage to heavy use customers, such as a business using wet processing in textile manufacture".

2.4.3 UK CHARGING METHODS 1973 to 1989

A number of key ingredients were embodied in the UK Water Act 1973 and its subsequent modification by the Water Charges Act 1976; specifically (Thackray, 1988):-

a) A charge can only be levied in return for a service, or when a right or facility is provided.

b) With effect from 1/4/1981 charges must have regard to cost.

c) From 1/4/1981 charges must not unduly discriminate between classes of (legal) persons.

d) Major tariff structure changes should be phased in over 5 years or less.

These Acts not only provided the legislation for unprecedented organisational change, in the UK Water Industry, but also provided the framework for charging customers directly (Thackray, 1988). The study also considered the impact of the Public Utility Transfers Act (1988). The following statement was made:

> "It seems likely that this (legislation) could lead over a period to less variation and use of local initiative in devising tariff structures, and on the basis of government's track records in specifying other economic criteria , to sudden and relatively erratic shifts in policy rather than the gradual but uneven evolution usually found in a group of less fettered utilities".

A detailed review of the 1988 Act reveals that duties of the Water Companies were changed from ; "having regard to the policies of the (then) Water Authorities in whose region they are" to ; " having the same duties and centralised control regime" thus reinforcing Thackray's (1988) concerns about loss of regional variation and hence creative development through system evolution to meet local circumstances.

Evidence of government influence attempting to dictate charging policy appeared in 1986, during the "privatisation" debate. Evans (1986) stated; "the crucial issue is the level of investment needed by the water industry in the years ahead. Several authorities argue that they have a mounting backlog of work following Treasury-imposed economies". The report went on to describe how the Chairman of Thames Water was so infuriated by Treasury tactics in forcing steep rises in water charges, to increase government revenue, that he floated the idea of industry privatisation.

In 1986 "Thames had planned a rise of just 2% but was forced to increase the Treasury impost on London's 11 million water users by 6%". A similar battle had occurred in 1984/5 when "a 3% rise was sought but government forced 10%". Thames was therefore in credit but the Treasury had been extracting substantial profits.

From the government's point of view, the move towards privatisation had been a deliberate and successful drive to water industry self sufficiency. Evans (1986) noted that "in 1974 the industry borrowed almost as much as it invested but moved to be 60% self financing in 1980 and 90% in 1986/87".

Between 1974 and the move to privatisation in the mid to late 1980's the Goverments pursued the concept of "Economic Equity". Applied rigorously, (Thackray, 1988):-

> "this concept involves the customer paying the full economic cost (or opportunity cost) of the service he receives, regardless of social, historical or even financial considerations."

Economic equity was steadily weakened, by legislation and regulation, in favour of the concept of a rate-of-return during the run up and implementation of privatisation (Thackray, 1988).

For example (Evans, 1986) for the year 1986-87 the rate of return on assets was set at 1.6%. This criteria was used to limit investment to £910m during the year which was 13% lower than the industry required. Rate of returns in previous years were 1.4% (1985/86) and 1% (1984/85).

Between 1981 and 1985 the average UK water bill rose by 43% compared to a gross rise of 20% in RPI. Fig 2.1.

Chesworth (1991) reported that between 1985 and 1991 water bills had risen by 57%, measured against RPI of 32%. In 1985 water and sewerage bills averaged £86 compared to £134 in 1991. From 1/4/91 they were £150. This was due to the requirement to raise £26b to fund proposed investment programmes over the next decade. The article quotes OFWAT as indicating that: "water bills would soar by more than 50% above inflation in the current decade."

Roland Boyes MP, presented Labour Party concerns, during an interview (McNab, 1986), by outlining opposition to either metering or licence fees and advocating its "fair rates" policy.

Green (1989) argued that due to the complexities of the interlinkages between water industry, user, environment and the time dependency of these costs a pricing structure with sufficient "requisite variety" would be difficult to devise. Further if water metering were adopted and customers charged on the basis of water consumed, then this would hit those PLC's which currently had surplus capacity.

The article observed that "not only industry but also households and the environment are engaged in inputting, processing and discharging water. Consequently setting charges to the customer , solely in terms of a price per unit of water supplied to them, would be unlikely to result in a system optimum".

Bringing the debate to a national level OFWAT launched its "Paying For Water, a time for decisions (Director General, 1990) document as a consultative paper. The document examined issues relating to methods of charging and tariff structures.

In its introduction (p5) OFWAT made reference to the fact that not only were: "most domestic customers charged on a tariff related to rateable value" but that: "Generally metered customers are subject to a standing charge which differs throughout the country." The report also pointed out that the mix of a high proportion of standing charges and high levels of minimum consumption "fixed charges" presented customers with minimal incentive to control their water demand.

The consultation document highlighted that charging policies need to achieve fairness, equity, sensible incentives, simplicity and comprehensibility. In a separate element of the same report, OFWAT reiterated that "charges for water and sewerage are not taxes, and so ability to pay would not be a good basis for them." The report stressed the philosophy that: "charges should be based on costs".

Hansard, (20.2.89), confirmed the Government's intention to abolish domestic rates as a mechanism for water service charging. Nicholas Ridley stated "Although the Government regards metering as potentially the fairest method of charging, it will be up to each undertaker to decide how it wishes to charge". In practice the concern expressed (Thackray, 1988) appeared to be confirmed, i.e. freedom of choice with respect to charging practices was being eroded in favour of metering.

There was and is, however, some freedom to consider options other than metering and the following list provides alternatives, compiled from numerous sources:-

a) Fixed charge £RV
b) Metering
c) Licence fee
d) Charge per adult

e) Licence fee plus charge per adult
f) Charge per property area
g) Number of rooms
h) Water using fittings
i) Income/expenditure tax

National debate and practical constraints selected just two options for detailed consideration. Thus the exhaustive list of 9 options was, in the UK, reduced to two possibilities considered practical. These were:-

a) Metering
b) Licence fee

The remainder were rejected due to either the cost of collecting and maintaining a suitable system or the non-correlation between consumption and charge. Further the "no discrimination " rule was considered to be flaunted by relating many options to an ability to pay.

At South Staffordshire Water the Licence Fee approach has been expanded into a banded licence fee (Thackray, 1990), which in general appears to be an acceptable alternative to the industry. However whilst there may be some correlation between size of property and quantity of water consumed, such a method does not provide incentives for customers to control consumption. Nor does such a system regulate use and payment. The system does however reflect the argument that services comprise a high proportion of fixed costs (Hodges 1988). In other words, generally it costs as much to make services available to small properties as to large ones (in the short run) and banded licence fees are cheaper to administer than metering.

Through its Customer Service Committees OFWAT, in 1991, questioned the public over preferred criteria for water service charges. The total response was low (Rees 1992) The returns published by the Director General (December 1991) showed a preference for payment according to use. Customers were asked if they preferred:-

1. A flat rate licence fee per household.
2. A household charge that would depend on the size and characteristics of their property.
3. Water metering.

In a article which was broadcast on the national radio and TV networks the National Consumer Council's Deputy Director, Mr Simpson (July 1992), criticised OFWAT's meter survey as misleading. The article, and subsequent national debate, suggested that consumers had not been informed about cost implications of household metering and therefore the widespread support inferred from the survey was flawed. A preferred option would be to invest in reducing water lost to leakage. This would be of greater benefit to customers and the environment and would avoid an expensive and potentially harmful social measure.

This view was refuted by the Director General in person (Byatt, 1992) who stated that "it is Mr. Simpson who is misleading the public in suggesting that OFWAT wants a crash programme of universal metering". Also Mr. Simpson has "not understood the relationship between metering and leakage" in that "of the 25% of water lost through leakage, possibly up to half that figure is lost from customer's own pipes".

The water industry considers metering as something of a dilemma. External installation is preferred for access, maintenance and as a clear definition of the customer/company boundary. However it is also the most costly installation point. The National Metering Trials (WRC 1990), confirm the fact of lower operating costs for external meters.

Buchanan et al (1989) stated that:

> "an additional £30 or 32% would be added to average annual water bills to fund costs of meter installation, maintenance, billing and reading".

Welsh Water (Brain, 1988) reported that:

> "the additional cost of reading and billing customers equated to £2.70/year/account. Further the maintenance repair and replacement cost of meters would be at least £10/year".

For Wales, the article computed that, these costs would jointly represent a 9% increase in overall charges.

The high costs of metering can, potentially, be offset against reduced consumption. However substantial savings are only achieved through the deferment of capital projects. To achieve such savings reductions in demand of 20 to 30% are required (Hodges, 1988). The article reports that records revealed savings of approximately 10% could realistically be achieved. This would appear to render the metering option a non starter. Demand management linked to metering and the philosophy of price elasticity are reviewed separately in sections 2.5 and 2.4.4 respectively.

The "Paying for Water" document (Director General, 1991) agreed that; "the impact of metering on demand is unlikely to be sufficiently great for the savings in resource costs to exceed the costs of immediate general installation of meters." It was further argued that the balance would change with increasing cost of water, improvements in meter technology, customer groups who could reduce demand substantially and for areas where resource shortages are most pressing.

The most extreme combination of all of these factors was employed in examining the case for water meters in South Staffordshire Water (Capener and Carnell ,1992). The study modelled the economic effects of an installation programme in two separate geographical areas. The locations were selected to present conditions most likely to enhance the economic benefits of metering, i.e. where resource supplementation was both most required and most costly. Surprisingly, even at these extremes, in excess of a 17% reduction in preceding year's average per capita consumption was required for investment to break even. This model analysis was based on zero standing charge for metered customers and installation rates close to half of current costs. Without these variables being set to grossly favour metering it is estimated that consumption reductions, through metering, in excess of 30% would have been required. The report concluded that:

> "if not viable for the selected areas, and treated with the most optimistic installation and running costs, metering is not considered to currently be an economic prospect for any area of the Company."

The Metering Report (Watts, 1985) determined that with the advent of metering "the majority (of water customers) would neither gain or lose". The Chairman of the National Metering Trials (Gadbury, 1991) stated that "Metering had never been intended as 'universal' ".

At the 15th African Water Engineering and Development Conference, the subject of paying for water was debated (Usman et al, 1989). It was postulated that "willingness to pay" was based upon the findings identified by Whittinton et al (1988) namely:

1. Perceived health benefits
2. Convenience
3. Amenity
4. Time savings and economic benefits
5. Levels of service
6. Existence of alternative sources
7. Income
8. Price
9. Different uses
10. Different determinates
11. Value of womens time and
12. Family size.

Schelette et al (1991) examined the price elasticity of urban water supplies. The report summarised that three characteristics generally affect the price elasticity of a product. These were stated as being:

1. The quantity and availability of its substitutes
2. The importance of the product in the buyers budget.
3. The number of its uses.

Schelette continued by stating that: "These characteristics do not necessarily work to influence price elasticity in the same direction. For example, water has many uses, implying elastic demand. The lack of substitutes and the fact that it represents only a small part of household budgets however cause the overall tendency to be inelastic."

As an example of price elasticity, of demand for water, Schelette reported that from study of American "increasing block rate charging structures", reported in 1980, the demand for water was: "generally inelastic, ranging from -0.27 to -0.61".

Usman et al (1989) reported African average day price elasticity demand for water ratios of between -0.2 and -0.4. This suggests that as price is doubled consumption drops by 20 to 40%.

Schelette et al (1991), stated that; "most potable water use, drinking, cooking and bathing is a necessity with little room for elasticity. As water consumption becomes more discretionary i.e. irrigation, car washing and recreation, its demand becomes more price elastic." and customers have the 'freedom'to adopt a direct choice about its usage.

The report continued: "The determination of price surcharge effects, upon customers, requires delineation between necessary and discretionary use. Seasonal variations can result in corresponding price elasticity impacts. For example when the season dictates water usage for garden watering, greater sensitivity to price can be expected".

However Usman et al (1989) also found evidence in Africa that individuals were willing to pay only if they perceived the level of service to be acceptable. He indicated that if the service was acceptable then low income communities would readily pay between 3 and 5% of their income for water. The report, however, suggested that some levels of service were very basic yet customers continued to pay between 3 and 5% of their income for water.

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Supporting this sentiment from further practical experience; Usman etal (1989), reported that Cairncross (1988) found:

> "the poorest groups in Khartoum were having to pay 120 times more for water, from street vendors, than the better off paid from piped connections".

This sentiment was also echoed in Okun's (1988) examination of Water Prices in developing countries. He provided evidence of water being sold by Entrepreneurs in containers, from 20 to 2500 litres, at prices between 20 and 100 times the rate for piped supplies. This affected typically 8 to 10% of the population. The study also showed that water utilities, in general, did not receive any income from such ventures.

2.4.5 TARIFFS

Laugeri (1988) pointed out that:

> "the objective of tariffs is to ensure optimum use is made of water resources whilst not compromising the water utilities financial situation".

Several approaches to Tariff fixing were discussed by Usman et al (1989). These are summarised as:

a) Increase Tariffs in line with inflation (politically and socially acceptable)

b) Set tariffs to recover operation and maintenance costs plus full amortization of capital costs.

c) Set tariffs to provide a target rate of return on fixed assets employed.

d) Use long run marginal costing, which is a method of considering and fully funding future costs of expansion schemes.

The UK water industry is reported to consider the following criteria, for tariff design, as desirable; (Garrett, 1987):-

a) Easily understandable by the customer.
b) Practical and appropriate to available technology.
c) Capable of expansion for wider, future, use.
d) Must satisfy charging legislation.
e) Income recovery, must have acceptable risk of income loss.

Examination of these criteria have resulted in five suggested forms of tariff:-

a) Flat rate.
b) Rising Block.
c) Declining Block.
d) Seasonal Tariff.
e) Peak tarifff

Usman et al (1989) offered the argument that:

> "it would be beneficial if rates charged reflected the value of resources rather than historical cost. Rates should signal costs of incremental services. Hence the customer is aware of the costs of his choice and can influence his willingness to consume at that rate".

Marginal costs are a measure of:

> "additional costs for the next unit of output. For the short run they are based on variable operating costs. For the long run they include necessary investment costs".

OFWAT (Director General,1991) defined short-run marginal costs as:

> "the cost changes experienced immediately following a change in demand."

Long-run marginal costs were defined as:

> "cost changes experienced once the industry has adjusted to a different level of demand, and in particular adjusted its capital stock."

Usman et al (1989) continued:

> "The use of the long run marginal costing approach appears to be unacceptable because it, in general, leads to very high tariffs. A compromise solution is to incorporate the marginal rate as the second or third in a block rate structure. Initial consumption providing for basic need would be charged at a lower rate and higher or discretionary consumption at the marginal rate. In general water is charged at a rate which does not reflect full costs of the next incremental service step".

When considering charging strategy for the UK household market OFWAT (OFWAT, 1991) stated that: "water charges need to be related to the full continuing cost of supply." Further this was fully identified as including; environmental costs, capital costs and operating costs.

The National Metering Trials (WRC, 1990) include tariff investigations to determine the benefits of each. To permit the trials to be undertaken Section 30 of the 1973 Water Act was specifically repealed. Details of the effects upon water consumption are studied in section 2.5.

The Director General (Byatt, December 1991), considered that UK fixed charges were too high; particularly when compared to other utilities. He suggested that standing charges should be forced down to cover "customer related costs" such as billing and directly associated activities only.

This stance was reinforced in the Paying For Water document (Director General,1991) which stated: "OFWAT is sceptical of the argument that 'fixed costs should be recovered through capital contributions or a standing charge and variable costs through a volumetric charge'. Neither is it convinced by the argument that the use-related component should be based on estimates of marginal cost which take a short term view of the future capital programme, with the balance of accounting costs recovered from the standing charges."

For comparison the current proportion of standing charge to average UK household bills are: water 49% ;gas 11% and electricity 12%.

The Watts Report (1985), concluded that:

> "the industry incurs substantial investment to meet peak demands. In general, charges do not reflect this".

The report also determined that:

> "the costs of delivering water, in particular at times of peak demand, are higher than previously recognised. The industry can continue in this manner, providing capital works to meet increased demand, which encourages customers to use more. Alternatively, use could be discouraged, thus obviating the need for capital investment and offering some environmental protection".

The aspect of "discouraging use" relates to control of customer demand. This is discussed extensively in section 2.5.

An article, considering UK resource capacity, (Chesworth, 1991) emphasised the need for control of demand and reported that:

> "1 in 5 of the (UK) population were exposed to a high risk of water shortage in 1991. Nearly half of the population were subject to restrictions on water use in 1989/90. With water shortages becoming increasingly common, a way of encouraging water preservation is needed".

Thackray (1988) argued that "to a much greater degree than any other utility, the water industry provides capacity, available night and day, for the customers convenience. It is this capacity reservation and availability which costs money that requires paying for".

Warnings of rising costs of water services, particularly when linked to incentives positively encouraging customers to conserve water caused NALGO (1986) to comment that: "water is not an optional commodity". Concern was expressed about prohibitive costs of water forcing consumers to take either, less water than required to meet health and hygiene standards or, at worst, face having supplies cutoff.

Currently, in the UK, disconnection for non-payment is a major issue, but under the 1989 Water Act it is the courts who decide who can and cannot be cutoff. "This is as it should be . The industry is coming under stricter controls, particularly financial, is not in the public sector and should not be required to act as a Social Agency" (Herrington, 1990). The statement continues by making the observation that "customers will appear to double up uncomfortably in their alternating roles of water customers and friends of the environment".

.5 DEMAND MANAGEMENT.

.5.1 INTRODUCTION.

In a very public manner water resources are becoming increasingly overloaded. Frequently water companies in the UK report shortage, implementation of hosepipe bans or application for drought orders; for example Water Bulletin (1991). That this should even be so over winter periods is alarming and indicative of a mismatch between resources and demand.

Measures are becoming necessary to prevent permanent shortage and resource depletion. Water utilities contemplating this position must make a choice between increasing resource capacity or conserving existing supplies.

With increasing environmental concern being voiced from pressure groups, NRA, OFWAT and the water industry itself. Utilities will be forced to make, in simple terms, existing supplies go further. This element of the research examines options available to achieve such an objective and reviews achievements relating to demand management.

The management and protection of water, soil, forest and wildlife resources were discussed by OECD Environment Ministers (OECD, 1989) at a meeting in 1985. An integrated approach to the management of resources was recommended to ensure long term environmental and economic sustainability. The resulting report, OECD (1989), included a chapter on " Improved Water Demand Management". Three ways of satisfying increasing customer demands for water were identified:-

1) Increasing supplies of the basic service.
   These "may however be increased by the construction of more treatment, storage and transportation facilities."

2) Supply-management.

" A given supply system may be made more efficient by, for example, artificial recharge of reservoirs and, where appropriate, giving lakes and reservoirs new river regulating roles. In this manner more output may be obtained from a given system;"

3) Demand management.

This " term embraces all those measures which seek to bring demands into line with supplies rather than vice-versa."

In the appendix on "Guidelines for Water Demand Management" (OECD,1989) it was stated that: "There is significantly more scope for policies to implement demand management than for supply reallocation."

Binnie (1992) described Demand Management as "measures which reduce or reschedule water use. The main reason for demand management is that it is expensive to meet all water demand all of the time".

A classic definition of Demand Management was made by J F Flack (1981):-
"making more efficient use of existing supplies through structural, operational, economic and sociopolitical means"

In a study of Denvers "bluegrass lawns" (Wiley, 1983) revealed householders using an average of 3.8 to 5.0 cm per week to water gardens when only 1.7 cm was required. In this study, garden watering represented 80% of residential summer consumption. "The potential to influence overall consumption through behavioural change of just one factor", the article concluded, "is very significant". Denvers Water Department were looking for demand reductions of 20%

From experimental work at the Building Research Establishment (Rump,1978) it was considered that: "One of the most promising areas for applying demand management is in the domestic sector as domestic usage accounts for almost half of the national (UK) water supply."

Finally in this respect the desirability of, and mechanisms to, achieve water conservation through "demand management" were identified by the United States National Water Council (Flack 1981) who declared:-

"In planning to meet future demands for municipal and industrial water, full consideration should be given to the possibilities for reducing water withdrawal by metering, by imposition of pricing systems that encourage more efficient use of water, by changes in building codes, by reducing leakage, and by other measures as an alternative to increasing supply, or as a means of minimising the necessary works."

These approaches are examined in detail in the following section

2.5.2 REVIEW OF ESTABLISHED METHODS

The Water Resource Management report (OECD, 1989) categorised five principle policies through which Demand Management could be pursued. These included pricing, regulation, education and operational control. The fifth element was described as "increased flexibility in water use rights". This was considered to provide an mechanism through which "a water authority would be relieved of the responsibility of devising, implementing and administering a charging scheme or other rationing system." As described it parallels supply management practices and was therefore not considered as appropriates for this research.

Overlap can occur between the four remaining categories i.e. a tariff pricing scheme can be designed to penalise excessive consumption. In such an example the customer retains the choice of usage; He may however volunteer to reduce consumption in order to actively reduce water bills. This example serves to illustrate overlap between educational and pricing policies. Combined approaches are examined further at the end of this section. Each of the four identified categories are reviewed separately.

2.5.3 EDUCATIONAL POLICIES

A voluntary appeal to customers has the affect of achieving conservation through education and co-operation. It can be particularly powerful when widespread media interest is involved. April 1992 saw Water Companies in Southern England using established personalities to sell their message. Of particular note was the input by David Bellamy, the well known environmentalist, on behalf of Three Valleys Water,(Three Valleys, 1992). It is expected that such representation will add authority and a note of impartiality to a method which loses its impact with time and repeated use.

Voluntary restraint, through education and mass "appeals", has been used as a first defence when water utilities are faced with a crisis. At South Staffordshire Water, this has occurred twice, in recent history, once during the 1976 drought and again as a result of the 1982 strike (Capener, 1992). Binnie (1991) reported that appeals to the public for voluntary restraint achieve typical savings of 15-20%. However the conclusion is also drawn that "With a privatised industry and changed public perception, the response may be less in the future."

Similar problems of water shortage occur globally Ishibashi (1991) described 20 to 25% savings achieved through voluntary appeals in Japan.

In the UK, under condition J of each company's Instrument of Appointment, the Director General sets levels of service for water availability. With respect to major publicity campaigns, requesting voluntary savings, this is interpreted as occurring, on average, not more than once in 20 years. The Standards DG1 and DG4 embraces this aspect of interruptions to water supplies and are monitored closely to ensure compliance.

2.5.4 REGULATORY POLICIES

First in the list of U.K. Legislative measures is the hosepipe ban. The provision for such a restriction initially appeared in the 1945 Water Act, Section 16, and has been maintained through successive legislation. It is now to be found in Section 76 of the Water Industry Act 1991:

The provision is intended to prohibit the use of water, through a hosepipe, for watering gardens and washing private cars. Reference to the use of this legislation indicates how widespread its effects can easily become: "During 1990, 18 million people in England and Wales were subject to a hosepipe ban." (Binnie, 1991). Further to strengthen its effects a "Water Company in Southern England announced that it had introduced a fine of up to £2000 per incident to strengthen the imposition of its drought order." (Water Bulletin, July 1992).

The second stage, through legislation, is the "Drought Order". This authorises the use of measures which have limited effects on water courses. Favourites are firstly a reduction in the release of, impounding reservoir, compensation supplies to maintain downstream river flow. Secondly an agreed increase in, licensed, abstraction rates. The due process involves publication of the proposals in the press. Objections can delay or prevent the application being granted by the Secretary of State. The National Rivers Authority will normally only support a drought order if a hosepipe ban has been imposed.

In extreme circumstances a third conservation measure is available: The Secretary of State can specify a list of restricted water uses. This provision, available through Section 74 of the 1991 Water Resources Act, includes prohibitions on washing of buildings, watering of public gardens and golf courses, car washes etc.

The same order also allows for such drastic measures as "rota-cuts" and restricting communal supply via standpipes. The national drought of 1976 saw rota-cuts introduced in South Wales and standpipe supplies in South West England.

Each Company sets its own standards of service, in this respect. A typical expectation, interpreted from the Standards DG1 and 4, would be:-

TYPICAL MINIMUM STANDARDS

* HOSEPIPE BANS APPEAL FOR VOLUNTARY RESTRAINT	once in 10 years
* DROUGHT ORDER FOR COMPENSATION WATER, ADDITIONAL ABSTRACTION	once in 15 years
* DROUGHT ORDER FOR NON-ESSENTIAL USE	once in 20 years
* EMERGENCY DROUGHT ORDER FOR ROTA CUTS, STANDPIPES ETC	once in 100 years

Source, Jack 1992.

2.5.5 OPERATIONAL CONTROL POLICIES

The conservation of on-property water usage, through the application of physically restrictive devices, can be approached in two ways. The first and most widespread, particularly in the US, relates to the introduction of equipment at the point of use. This may be a modification to an existing appliance, i.e. reduced toilet flushing by permanently displacing water held in the cistern using "toilet dams or bags". Alternatively brand new, low water usage equipment may be installed either to replace inefficient fittings or, as standard, to new properties. I.e. The replacement of a conventional 10 litre flush toilet with a 7.5 litre flush system.

The second option is to influence the entire household supply. This may be achieved due to plumbing design or altering standards of supply, i.e. pressure and perhaps flow. For example, in the UK, anecdotal evidence suggests that this was commonly achieved, accidentally , through the use of indirect plumbing systems, i.e. using storage tanks to feed all appliances except kitchen cold water taps.

The most common forms of remote demand management are pressure control and leakage control. Both have the potential to conserve water and both are pursued without the customers involvement. Remote demand management discussed in this section is considered as complimentary to such standard operational practices.

It is implicit that the application of conservation measures for potable water permit the consumer to retain acceptable standards of supply, apart from times of crisis. The interpretation of "acceptable" remains to be defined and will be subject to influence dependent upon availability of water resource and climate throughout the world.

As described, in chapter 1, OFWAT have set a range of standards-of-service for the UK. With reference to conserving water, through the use of demand management, sections 2.5.2 and 2.5.3 presented interpretations of standards-of-service relating to educational and regulatory policies. Standards-of-service were also developed to provide an indication of the adequacy of the distribution system to meet customer needs. These are DG2 and DG3.

The DG2 reference level is defined as 10 metres head of water pressure at a flow of 9 litres per minute measured at the properties boundary. This is further specified as achievable under normal operating conditions and is considered reasonable for normal daily usage.

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DG3 is the standard which monitors properties which have supplies disrupted for more than 12 hours without prior notice. This excludes properties were failure was indirectly associated to an unplanned incident,such as a burst main. Table 2.1 summarises performance against relevant DG standards for England and Wales during 1990/1991.

To determine what measures are available an extensive review of practices, split into "point-of-use" and "remote" physical conservation methods, was undertaken. A wealth of information was available, the remainder of this section is devoted to presenting a flavour of experiences linked to these two identified categories.

2.5.5.1 CONSERVATION AT POINT-OF-USE (REDUCING WATER CONSUMPTION IN DWELLINGS)

This section considers the potential to influence consumption through outlets in the property. Certain appliances operate with preset volumes of water i.e. washing machines and toilets. Other items are dependent upon customer behaviour such as washing hands under a running tap, filling the bath or watering the garden. Either category presents opportunities to influence water usage, by limiting flow throughput or reducing the required quantity. Thus showers can be throttled and toilets designed to operate with lower flush volumes.

Before considering a variety of outlets and appliances in detail, an overview of household usage is presented to indicate relative volumes consumed for a range of normal activities. Binnie (1992) reported upon water usage and appliance ownership for a household in South East England.

HOUSEHOLD WATER USAGE.

ACTIVITY	LITRES / PERSON / DAY
WC Flushing....................	35
Clothes Washing................	20
Dishwasher.....................	11
Personal Washing...............	36
Outside Use....................	.9
Miscellaneous Cooking, cleaning drinking etc.).........	35
TOTAL........	146

HOUSEHOLD APPLIANCE OWNERSHIP

Appliance	Ownership Level %	Use	Consumption Litres/Use	Consumption Litres/Day
W.C				
Full	80	4/day	9	29
Dual	20	4/day	7.5	6
CLOTHES WASH				
Auto	65	4.75/hr/wk	102	17
Non Auto	22	1.9/hr/wk	90	2
Manual	13	1.9/hr/wk	50	1
DISHWASHER				
Machine	15	6/hr/wk	45	2
Manual	85	20/hr/wk	10	9

(Source adapted from Binnie, 1992)

It can therefore be seen that, as a single item, toilet flushing accounts for almost 25% of UK household consumption. As a consequence this appliance has received, probably, the greatest attention from manufacturers and the water industry

2.5.5.2 TOILETS:

The successful operation of low-flush toilets relies upon a combination of cistern, bowl and trap design. Successful combinations allow a lesser quantity of water to scour the bowl and siphon the contents out. Lillywhite et al (1987), undertaking research into low-flow toilets, concluded that it was feasible to operate a standard 9 litre flushing toilet with 6 litres. Site performance was adequate regarding pan clearance and also flow in drains. Flush volumes below 6 litres would work, but specialist pan design became critical to ensure clearance. An estimated 2640 Ml/day was used just for toilet flushing in England and Wales during 1986.

Rump (1978) reported that a Swedish close-coupled suite gave good results with a 2.5 litre cistern.

Prior to the introduction of U.K. Model By-laws in 1986, an alternative to low-flush WCs, the dual flush toilet, had become a bye-law requirement. These WCs discharge either the full, conventional, cistern volume of approximately 9 litres or a reduced amount of approximately 4.5 litres. Selection is made by the user depending upon flushing requirements. In practice anecdotal evidence indicates that consumers tended to misuse dual flush toilets and in general even more water was consumed than with conventional toilets.

The move to enforce the use of dual flush toilets was abandoned in favour of the current bye-law requirement which requires new toilets to use a 7.5 litre flush, by 1993. Lillywhite (1987) concluded that "the most cost effective method of reducing the domestic component of water consumption was to fit low-flush toilets".

Maddaus (1987) reported that non-conserving, older design, toilets used from 19-26 litres/flush. Whereas Low-flush toilets use no more than 13 litres/flush and very low-flush units, 5.7litres/flush. When applied to the average residential rate of 4 flushes per person per day this represents a saving of 30 litres per person per day, low-flush, and 60 litres per person per day, very low-flush.

It became apparent as a part of the work undertaken by Maddaus (1987) that specialist firms installing retrofit equipment to blocks of established apartments also discovered that 20% of the aged non-conserving toilets leaked. It was estimated that each leaking toilet accounted for 91 litres per day.

Numerous other studies confirm the water conservation available when retrofitting or replacing toilets with low water use fixtures. Examples are: Vickers (1990) estimated 57 to 78% savings in this category of plumbing. The article also reported that Siegrist et al (1981), measured savings of 75% excluding toilet leakage, which was separately estimated as 20%.

White (1990) reported that a study in Germany produced savings of 22% in total consumption when "modern" point-of-use fittings were installed in a block of flats.

APPLICATION OF LOW WATER USAGE DEVICES TO NEW HOMES

TABLE 2.2

DEVICE	WATER SAVING	GROSS SAVINGS
Toilet Low Flush	7.5 l/flush	30.3
Toilet Very Low Flush	15 l/flush	60.6
Low Flow Showerhead	0.09 l/sec	27.3
Low Use Dishwasher	19 l/cycle	3.8
Low Use Clothes Washer	22 l/cycle	6.4
	per capita TOTAL	98.1

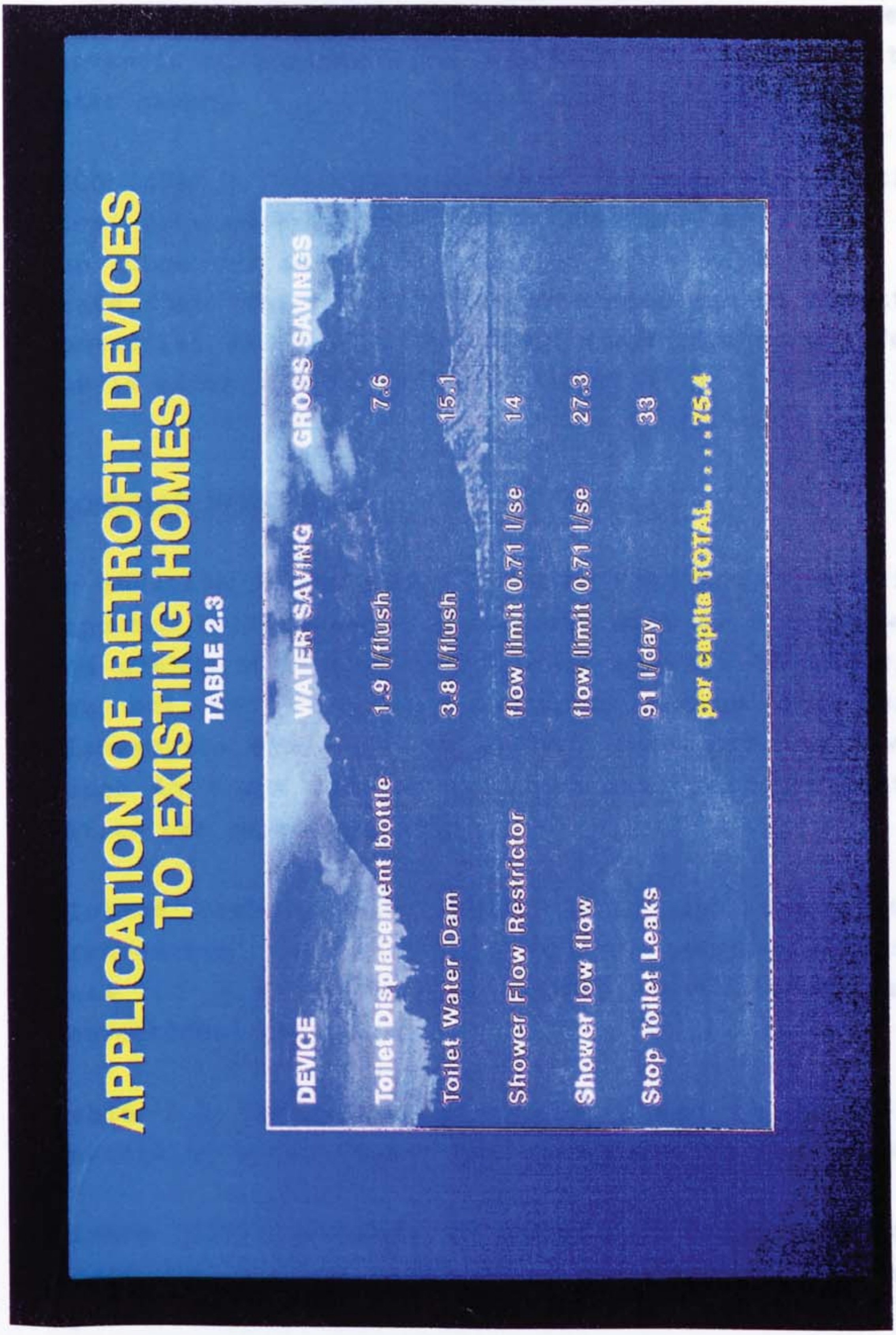
Further in this respect OECD (1989 p73) reported that: "toilet economy measures treated as investments have been found to give annual rates of return of up to 60 per cent in England and Wales." Finally, in the same report, OECD stated that: " the largest single appliance or habit consuming potable water is probably the toilet; it is estimated to be responsible for about 20% of the public water supply in England and Wales."

2.5.5.3 <u>SHOWERS:</u>

Maddaus (1987) reported on the savings generated by "low-flow" showerheads. He found that average shower time was 4.8 minutes per-person-per-day. That low-flow shower heads saved 27.3 litres-per-person-per-day and in doing so required less energy to heat the water. This translated to a saving of $8 per person per year for gas heating and $26 per person per year for electric. In addition customers also benefited from the direct savings in water consumption. Typical costs, at 1987 prices, for providing retrofitting equipment were $15 per household. Vickers (1990), also reported on low-flow showerheads, finding a net reduction in throughput of 34 to 50 % per annum.

Demand management using controlled shower emissions was discussed by Environment Ministers (OECD, 1989, p75). Very high shower use(40l/hd/day) was reported for USA and Australia. California is the only location reported as having plumbing codes regulating shower-flows. Methods of controlling flow were reported as being: "limited to supply restrictors, air compressors and the introduction of 'misting' showers with very fine sprays." This latter method was indicated as being uneconomic and creating "dissatisfaction" in the UK.

The benefits of atomised shower sprays was also considered by Rump (1978). In testing on a team of 15 individuals the atomised shower used 41% less water than a conventional shower. This was despite a (15%) longer period being spent in the atomised shower.


APPLICATION OF RETROFIT DEVICES
TO EXISTING HOMES
TABLE 2.3
DEVICE
WATER SAVING
GROSS SAVINGS
Toilet Displacement bottle
1.9 l/flush
7.6
Toilet Water Dam
3.8 l/flush
15.1
Shower Flow Restrictor
flow limit 0.71 l/se
14
Shower low flow
flow limit 0.71 l/se
27.3
Stop Toilet Leaks
91 l/day
33
per capita TOTAL 75.4

2.5.5.4 TAPS:

Vickers (1990) examined the benefits of low-use taps. She concluded that combined kitchen and bathroom taps account for 15% of American indoor consumption. Replacement of conventional equipment was estimated to produce 15 to 45% water saving.

OECD (1989 p 75) concluded that "Because tap 'Continuous flow' uses were probably small relative to 'volume' uses, the scope for savings is limited." The report went on to state that "The prospect for economies are much better in commercial and public buildings where the reason for tap use is often limited to hand-washing."

2.5.5.5 DOMESTIC APPLIANCES

In addition to bathroom fixtures (Maddaus, 1987) it was reported that domestic appliances such as clothes-washers and dishwashers used significant amounts of water, much was hot and therefore required energy for heating. Dishwashers available in America incorporating low-water usage in their design produced savings equivalent to 4 litres per person per day.

Clothes washers used about four times the volume of dishwashers and efficient designs consumed water at a rate of 6.4 litres per person per day less than conventional designs.

Table 2.2 indicates savings that can be generated by installing water conserving appliances to new properties.

Binnie (1992) provided an example of variations in water usage by washing machines. Consumption, for similar cycles, varied from a German machine requiring 68 litres to a UK manufactured machine accounting for 163 litres.

OECD (1989 p75) reported that for domestic appliances "the only reported enforceable codes laying down maximum use data were in California."

Whilst investigating the components of household demand, Thackray et al(1978), determined that automatic washing machines were "associated with a higher average consumption" whilst any other washing machine were not related to a higher domestic consumption.

2.5.5.6 COMBINED WATER SAVING POTENTIAL

Maddaus (1987) combined the savings from his studies to conclude that American internal residential use would be reduced by 10% if low-flow toilets, shower-heads and taps were fitted as replacement appliances.

Vickers (1990) is more ambitious, estimating that retrofitting, which is substantially cheaper than installing new appliances , the estimated 250 million American residences would yield internal (only) savings of 25% This represents savings of 3.4 to 8.4 billion (US)gallons per day

Figures 2.3 and 2.4 compare 1987 average water use in a conserving and non-conserving American home.

Figure 2.5 illustrates water use before and after retrofitting seven apartment buildings in Washington DC Note the savings include repairs to leaking toilet fixtures.

Table 2.3 indicates savings that can be generated by retrofitting devices to existing American homes.

As a drastic alternative, Rump (1978), considered in detail the possibility of domestic water recycling to the point of being totally autonomous in water. The conclusion was drawn that whilst technically feasible, especially if integrated with usage of rainfall, then: "complete autonomy in water is not a method that can be realistically proposed to effect a significant nationwide reduction in water demand.

2.5.5.7 REMOTE PHYSICAL CONSERVATION MEASURES

Conventional remote conservation methods are applied at district level by controlling flow or minimising leakage. Both have a very significant role in the operation of a water supply system.

Studies undertaken in three American cities, Maddaus (1987), confirms that water pressure influences water use. Typical water pressure of 80psi was reduced by 30 to 40%. Savings varied but showed between 3 and 6% reduction in normal usage. Reducing water pressure also saves the utility costs due to less power being required for pumping.

A sophisticated distribution pressure control system, developed by South Staffordshire Water PLC, repeatedly demonstrated savings when applied to areas already under existing pressure control. The system allows customers to dictate, within derived tolerances, the flow of water on to the district. Yet at times of low demand the control optimises flow throughput. Savings are attributed particularly to leakage reduction either on customer property or on the distribution system. Savings are attributed particularly to leakage reduction either on customer property or on the distribution system. Continuous monitoring of the system did, however, also indicate that genuine consumption patterns altered. Savings approaching 50% flow at night and 30% during the day were noted (Goodwin, 1993).

2.5.6 PRICING.

Apart from the on-going National Metering Trials, evidence of the design and experience of price based demand management is provided from outside the UK. In this respect the reader should be aware that UK per-capita water use is considerably less than most of our European neighbours and the United States (section 2.6). The scope for absolute reduction increases with consumption rising above basic needs. This is particularly so for countries with arid climates where outside usage is high.

It is usually assumed that increasing prices results in larger bills to customers and provides the temptation to conserve water. In practice the expected does not always happen. Palmini et al (1983) reported that "Apparently the public just does not respond to the substantial dollar savings on energy bills from installing (low-flow) showerheads". The following brief section is included to place in context customers perception and behavioural reaction with respect to the purchase of water

2.5.6.1 SUPPLY AND DEMAND.

A perfect market consists of "only one market and one market price" (Whitehead 1992). In practice "customers do not have perfect knowledge and those prepared to pay more can be charged more". If an item costs £1 and some customers would have been prepared to pay £2 then they are said to "enjoy a consumer's surplus of satisfaction". Similarly company surplus is achieved by sale price in excess of cost.

Cromwell (1988), provided a summary of the basic economics of piped water supplies and investigated consumers willingness to pay. Cromwell refers to Adam Smith's treatment of "the paradox of value" in "The Wealth of Nations". Smith was puzzled about how water could have so many practical and essential uses and yet be taken for granted as though valueless.

At the time, 1776, water was either inexpensive of free because it was in great abundance. Thus its value in market exchange was very low. However a little water is an essential of life for everyone; they would be prepared to pay very high prices for the first few units if they had to. Therefore, in normal conditions all people buying water experience very high consumer surplus at the going market price. Hence even doubling or trebling its price would use up only a small part of the consumer surplus to which it gives rise.

Cromwell surmised that the same relative cost environment persisted well into the Twentieth Century shaping attitudes and expectations accordingly. Safe drinking water became taken for granted. Cromwell concluded that "taken together the downward effect of the supply curve induced by rationalising charges and the upward effect on the demand curve induced by public information could eventually outweigh past imperfections and allow a true measure of willingness to-pay to become evident". He advocated that "programmes of public education and rate reforms would, eventually remove historically derived 'flawed pricing'and 'imperfect information' which have created the current social attitudes towards the value of water". As evidence Cromwell pointed to the expansion in the "unflawed" bottled water market in the USA.

In 1988, the market for bottled waters expanded by 15 percent. This, as currently in the UK, was despite the fact that substitutes cost 500 to 1000 times as much as tap water. The evidence available indicated that market share began to grow in the middle to late 1970's. This period coincided with increased public awareness of toxic chemical health threats. Cromwell believed it "more accurately represented the customers willingness-to-pay for safety" in drinking water.

The subject was considered by Environment Ministers (OECD, 1989) who concluded that the principle reason which had caused supply-management to be the option automatically favoured by member countries was: "the huge scale of subsidisation by central, regional and local government. This has encouraged the perception, held by both consumers and suppliers, that the basic water services are very cheap. The result has been overbuilt systems, public funds wasted and resources misallocated."

A further statement was made (Cromwell, 1988): "Excessive consumer surplus is being eroded in the U.K. and people are becoming more sensitive to price. Massive capital projects are being undertaken to fund years of neglect in the Water Industry". He suggested that these necessary works coupled with high values attributed to 'environmental protection' are likely to receive blame for reducing consumer surplus."

2.5.6.2 DEMAND MANAGEMENT AND WATER METERING

A study of water conservation measures (Maddaus, 1987) gave particular attention to savings achieved through water metering. 65 single residence homes in Denver were compared to a control sample of 77. Each residence was about 20 years old and all were of similar construction and in the same block. Metered customers used less water with savings ranging from 2% in winter to 25% in summer. This range represents the seasonal need to irrigate gardens. Overall average savings equated to 20%.

Schelte et al (1991) examined the price elasticity of water and determined that: "demand for water is generally price inelastic ranging from -0.27 to -0.61". There was no indication of either market sectors, countries or years to which the quoted elasticities related. The study concluded that; "no firm assurance could be given regarding how water consumption may change in response to higher rates because many other factors influence consumption patterns".

Binnie (1992) reported that "in areas where current consumption and climatic conditions are broadly similar to those in Britain, average daily reductions in consumption are typically 10 to 15%", table 2.4.

Early estimates of savings attributable to metering from The National Metering Trials are presented as Table 2.5.

Evidence from the National Metering Trials (Binnie, 1992) showed an increasing trend in consumption reductions. First year reductions were reported as 10% with the second year achieving 13% savings.

The Malvern and Mansfield Studies (Thackray et al, 1978) looked at household consumption in two towns. The first, Malvern, where consumption had traditionally been metered and charges levied by volume and the second, Mansfield, where customers paid by rateable value. The data shown in the report indicated broadly similar overall average consumption for both data sets. When this was re-cast into properties defined by social class, however, the conclusion drawn was that: "The average difference between the consumption of the two towns which could be attributed to charging by meter is of the order of 10%."

The recorded consumptions for both towns split by social group was:-

SOCIAL GROUP	MALVERN (pay by volume) lhd	MANSFIELD (pay by R.V) lhd
A. Professional	149.7	120
B. Managerial	113.8	116.6
C1. Clerical	104.6	100.4
C2. Skilled	80.5	97.7
D. Unskilled	74.4	92.8
E. Unclassified	104.5	75.7

(Source Thackray et al, 1978,p47)

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(Source Thackray et al, 1978,p47)

An examination of the survey and analysis methodologies from the Malvern and Mansfield study is presented in section 2.7.2

The growing importance of establishing impacts of peak demands upon supply systems was considered by OECD (1989). The report concluded that: " tariff structures do seem to affect peak ratio's strongly (United states' evidence)." The report went on to comment: "that only in Australia had this been taken into account for demand-forecasting."

Australian average day use fell by 20 to 30% with peak day consumptions falling by 50%

To provide experience of the application of water meters to customers homes the DoE and UK water industry organised the National Metering Trials. Four objectives were identified (WRC 1990):-

1. To measure household demand for water at each trial site taking into account various climatic areas and housing types.
2. To identify any change in demand through metered charging.
3. To identify the effect on demand of different metered tariff structures, including peak demand.
4. To determine the effect of meter location on consumption and levels of leakage.

Twelve trial sites were identified to provide a representative sample and to enable the effects of identified variables to be measured. The largest trial took place covering some 50000 households on the Isle of Wight. 11 other smaller scale sites, typically 1000 properties, were selected representing different parts of the country.

Initially, for the period 1st April 1988 to 31st March 1989, districts were monitored prior to individual domestic meters being installed. Equivalent daily demand figures were calculated by subtracting daily minimum night flows from daily supply totals.

Following installation, metered charging began on 1st April 1989. Data collected during the first year of the trial allowed comparison to determine effects upon consumption of charging by meter.

The range of daily consumption varied from 174 to 527 litres/property. The mean across all sites for the year equated to 371 litres/property/day. Analysis of data showed that peak demands occurred in the evening during the warm summer periods of 1988. These were attributed to garden watering and proved to be nearly twice the average hourly demand.

Subsequently with meters installed and properties in charge average consumption, for each trial site, varied from 271 to 480 litres/property/day. Overall average equated to 350 litres. Analysis by property type showed that most water was consumed in detached houses at an average of 430 litres per day and the least in flats and maisonettes equating to an average of 200 litres per day. Consumption was shown to be dependent upon occupation. Average figures were 168 and 550 litres/property/day for one and five occupant households respectively. From the Isle of Wight only, a gross difference in trial averages, amounting to 32 litres/property/day, was recorded between internal and external metered properties. Later debate concluded that this represented a measure of water leakage from underground supply pipes.

2.5.7 DEMAND MANAGEMENT IN PRACTICE

Examples of 2 studies where demand management was practised to deliberately cause water to be conserved are reported in this section. These differ from cases reported so far, such as Malvern and Mansfield and the National Metering Trials, whose primary intention was not focused upon imperative need to manage customers demand.

2.5.7.1 EAST BAY MUNICIPAL UTILITY DISTRICT

In May 1990 the American organisation, East Bay Municipal Utility District, reported on measures implemented to combat second and third year drought (Gilbert et al, 1990). A mixture of legislative, voluntary, physical and fiscal measures were introduced to the water using public in an attempt to achieve demand reductions of 25% and 15% in 1988 and 1989 respectively. 1987 saw the introduction of a voluntary (only) conservation programme with a goal of 12% reduction. The opportunity was also taken to acquaint the consumers (340,000 accounts) with mandatory conservation measures that could be introduced if drought condition did not improve.

As a result of the voluntary programme the 290,000 single-family residential accounts decreased consumption by 4%. Multi-family residences and non-residential consumption decreased by 3.5%. The programme was introduced from June to September to coincide with maximum demand. The combined result of the 12% programme was a very disappointing 3.5% decrease on 1986 levels.

It was apparent that if drought conditions persisted over winter a full scale conservation programme going way beyond voluntary measures would be required to balance shortfalls.

The drought did continue, with only 56% of normal precipitation.

The magnitude of the water shortfall was predicted to be 25% of normal summer consumption. Conservation targets of 20,25 and 30% were considered for feasibility and hardship to customers. The 25% level being selected as the minimum to meet the required consumption reduction. The target reduction was distributed amongst account groups in proportion to summer use in excess of average winter use. This reflected the peaks normally created by customers irrigating gardens, parks and golf courses etc. For single family residences this translated into a 32% reduction in normal summer consumption.

Achieving the targeted conservation levels would have resulted in a pro-rata decrease in water rate income to the utility. To compensate, the unit charge would have needed to be increased from $0.71/cu ft to $0.95/cu ft. However the $0.71/ cu ft charge was retained to moderate hardship on customers meeting essential needs. This was particularly so for low income customers who were believed to be conservers already because of income restraints. This support programme increased the revenue neutral rate beyond the calculated flat-rate charge of $0.95/cu ft. To compensate, a ceiling of 200gpd was introduced at the $0.71/cu ft conventional rate and a charge of $1.05/cu ft levied thereafter for single family residential customers.

To provide further financial incentive to customers an inclining block rate structure was established. A total of 5 steps ranging from the $0.71/cu ft, for 0-200gpd consumption, to $3.00/cu ft for water in excess of 1200gpd. The East Bay Municipal Utility District surmised that "price elasticity would have little impact in drought conditions" and that "the fiscal programme was intended to reinforce the total community conservation package".

An extensive advertising campaign was conducted using radio, billboards, newspapers, shopping-mall displays and presentations at educational establishments. Legislation was passed requiring customers to comply with onerous conditions such as:-

* "shut-off nozzles to be used on hosepipes.
* No laying of new turf.
* Only drought tolerant planting allowed.
* New service connections must adhere to a drought compliance order.
* Enforced installation of flow restriction devices in the event of prolonged non-compliance

55000 conservation kits were issued containing low-flow shower heads and toilet tank inserts. A survey conducted later indicated that 90% of the population installed these devices.

Single family residences exceeded their 32% target and returned a 38% reduction.

Overall targets of 25% for 1988 and similarly 15% for 1989 were exceeded returning 30% and 27% respectively.

Four out of five customer groups achieved targets. Only the irrigation group was off target. It was later realised that 70% of this groups consumption occurred during the summer months with very little consumption taking place during the winter base period.

$2.5 million was spent just on advertising and publicity campaigns

The administration of the mandatory programme resulted in 68000 phone calls and 56000 letters asking for information on variations from targeted consumptions. The computer system for implementation of the inclining block rate structure required 40 person months during the two three month trial periods.

2.5.7.2 EDWARDS UNDERGROUND WATER UTILITY DISTRICT

In response to its conservation programme The Edwards Underground Water Utility District, Texas (Olsen et al, 1987), conducted a survey to determine attitudes towards water conservation. The conservation programme had produced an estimated reduction in water usage of 8%. The subsequent survey assumed that this saving had been achieved with negligible effort by customer groups to conserve water.

A random sample of 303 consumers were selected and questioned over the telephone. Results were analysed using the standard statistical package for social sciences (SPSS).

50% of the respondents indicated that water conservation methods could be moderately effective in deferring new resource development. 22% stated that conservation would not be effective.

To make intelligent decisions regarding water resource and conservation issues, it was recognised that citizens must be in possession of the facts. The survey showed that 90% of the respondents had heard about the conservation programme on television, 77% newspapers and 56% radio sources. Other sources included public presentations 39% and brochures 29%. When asked how much information respondents had absorbed 52% stated very little and 32% only some. An inconsistency, noted during the survey, was that despite the disappointing lack of knowledge absorbed, respondents showed almost no inclination to change their source of information. The survey indicated that participative information sources, such as workshops, enabled the respondents to be most prepared.

When asked about the measures actually implemented the tendency was for respondents to undertake practices requiring minimal effort. 88% had checked for leaks, 82% reduced garden watering, 72% reduced car washing, 19% fitted toilet bags but 36% had installed flow restrictors to showers. These last two items were supplied in conservation kits issued free of charge. 80% of respondents believed that they had generally used between 5 and 10% less than the previous summer.

53% of respondents indicated support of conservation oriented rate increases, 33% opposed such measures and 14 % were either neutral or undecided. From the group in support, 25% favoured a 10% rate increase and 25% favoured a 100% increase. When asked what effect a 100% rate increase, approximately $10/month, would have on their consumption 50% stated no or little impact and 43% of respondents would try to reduce consumption.

Survey responses were cross-tabulated with respondents socioeconomic characteristics. Analysis showed that there was a perceived need across all groups and attributes for additional water supply in the region. However greatest response to requests to undertake conservation measures came from groups with lower years of education and also lower income. Conversely the majority of higher income groups and particularly white, ethnic, groups indicated they had heard of the conservation operation.

A noticeably higher positive response was evident from long term residents for implementing conservation measures requiring greater effort such as toilet bags, low flow shower devices etc. Similar patterns also followed education levels and household income.

Newcomers to the study region were more receptive to rate increases. Long term residents and respondents with fewer years of formal education were opposed to rate increases. Also higher age brackets, lower income, Hispanic and black respondents opposed rate increases.

Almost identical responses were made concerning whether respondents would use less water if rates were subject to a 100% increase.

In summary: Respondents clearly indicated mandatory control, requiring the implementation of conservation programmes, as a prerequisite to seeking funding for capital resource projects.

The cost of conservation measures would have to be absorbed by the water using public but this would be small compared to capital funding and has the advantage of political acceptance. The majority of respondents indicated that they would accept rate increases in this respect.

The author concluded his study by stating that "conservation measures are worth having and represent better value than conventional resource development projects. Water conservation must however be given water resource status". This implies that water conservation is assessed in the same economic terms as any other water resource.

From an engineering point of view the author stated that: "water conservation is perhaps the most flexible resource available because it can rapidly be brought on-line to aid deferment of capital resource programmes. To be most effective conservation programmes require vast publicity campaigns, repeated frequently, to support the mandatory and voluntary measures".

2.6 COMPONENTS AND TRENDS OF WATER CONSUMPTION

2.6.1 INTRODUCTION

A brief examination of international and UK trends in quantities of water consumed allows possible savings to be put into context. For example, simple comparison reveals the fact that North American per-capita consumption is three times that of UK. This is despite water metering being the normal method of charging. Consequently, unlike the UK, customers pay by volume but this does not prevent consumption of, comparitively, vast quantities of water. Conversley UK customers can consume what they want, without penalty, but consumption is relatively low.

How do the costs of water delivered to customers in the UK compare with other countries. What has driven acceptance of the "norm" higher in one country than another. This section examines some of the issues through literature.

Park (1985) sets the scene by introducing the concept of 'demand' (for water) being outside the precise economic definition . Data available is in fact a measure of how much water was supplied, or fulfilled demand, ie the customer may require supplies in excess of those actualy availabile. This is an important consideration having both positive and negative implications for Demand Management.

Agriculture remains as the worlds largest consumer of water accounting for 55% with industry 35% and domestic trailing at 10%.

Individual coutries are subject to very different trends. The UK with its climate and established industrial background is dominated by industrial and domestic water consumption rather than agriculture.

2.6.2 INTERNATIONAL COST COMPARISONS

To illustrate the UK position, with respect to demand for water and the provision of resouces to service future demand, it is relevant to examine prices levied for water. Stadtfeld et al. 1988, undertook such an exercise and extended the comparisson beyond direct unit costs. In 1988 prices ranged from slightly more than $0.22 /m3 in Italy to $1.0/m3 for Germany. At that time UK costs were shown as $0.5/m3 (approximating to £0.25/m3). A range of European prices are shown as figure 2.6.

When pursued further, the absolute ranking of UK costs, which appear to be 'average', can be seen as misleading. A comparisson of European water costs as a percentage of household income reveals a range from 0.3% , Norway, to 1.0% in Austria. The UK equivalent was 0.3%. It can be seen from examination of figure 2.7 that UK water bills therefore represent a smaller proportion of household income than most of our European neighbours.

2.6.3 HISTORIC CONSUMPTION TRENDS

Park (1985), provided a review of overall apportionment of water consumption and considered why UK demand across principle categories had shifted with time.

In 1985 the DoE, cited by Park (1985) reported that the bulk of 1973 water consumption, 63%, in England and Wales was accounted for by industrial purposes. Agricultural demand accounted for 0.5% and the remainder, 36.5, was consumed by households. The total demand was 42000Ml/day of which 42% was consunmed by C.E.G.B.

Aston University

Ten years later total demand had dropped by 20% to 33000 Ml/day. Industrial demand represented 49%, domestic consumption had risen to 50% and agricultural use to 1% . C.E.G.B demand had fallen to 36% of total but this represented a massive 75% of the industrial component.

The observed fall in total demand was attributed to the overall reduction in industrial consumption. This is partialy accounted for by rationalisation of abstraction by C.E.G.B and limited increase in efficient industrial water use. However the principle reason for the decline in, non C.E.G.B, industrial usage ,52% over ten years, was shrinkage in traditional industry due to recession. Peak decline occured, with respect to water consumption, ln 1979 and 1980.

Over the same ten year period unmetered consumption increased by 26%, for England and Wales. This was assumed to be due to increased domestic consumption. However because households were not metered both absolute values and trends are estimated. 1985 saw estimated per-capita domestic consumption averaging 125 litres/person/day.

Figure 2.8 demonstrates the rising trend of overall UK consumption for the period 1961 to 1990. Figure 2.9 more clearly defines that the latter part of the same period produced an overall decline in metered (trade) consumption from 1974 onwards. This is despite a growing element of metered households in this category.

Household usage in 1983 comprised 32% WC flushing, 17% bathing and showering, 12% clothes washing and 39% miscellaneous. The latter item includes hand washing, drinking, cooking, cleaning, luxury appliances and garden use.

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Pygall et al (1978) attempted to establish if social and economic factors influenced trends in water consumption between 1961 and 1975, analysis was split into metered customers (which included some households) and unmetered (which included a number of commercial and industrial properties.

In both cases a simple time trend explained more than 95% of the variations. However the study pursued variables which could explain the time related consumption trend.

Nationally, for metered customers, the results indicated a substantial relationship between industrial production and metered water consumption. Factors considered apart from time included; employment, investment, weather, and the price of water. In conclusion the best fitting equations included output and employment.

When examining unmetered consumption the report pointed out that this category was determined by subtracting national metered consumption from total water into supply. The remainder, therefore, included not only the majority of household and all unmetered commercial consumption but also leakage from the distribution systems.

Variables considered included gross domestic product, personal disposable income, average earnings, customer expenditure, numbers of domestic properties, population, climate and employment.

The resulting equation took the form:-

$$U = -7.067 + 0.0007587D - 0.001397SR + 0.0003427NXIP \quad (Rsq=99\%)$$

where, U= unmetered consumption.

D= number of dwellings for rateable value purposes.

SR=summer rainfall

and NXIP = employment in the non-industrial section.

The report noted that multicollinearity amongst the variables was evident. This was ascribed to the variables generally being related to "a clear time trend." None of the income and expenditure variables performed well. It was determined that numbers of dwellings and the co-efficients of income and expenditure were too closely related for their separate influences to be identified. The preferred variable, which clearly exhibited most stability, was the number of dwellings.

Regression analysis of unmetered per capita consumption demonstrated that the number of persons per dwelling and average summer rainfall were significant variables. In addition either an income variable or the number employed in the service sector was significant.

In the following sections of this chapter I have atttempted to examine issues specific to either industrial or houshold customers. The approach was deliberately chosen to avoid elements of confusion which may be generated by, for example, elements of household in the metered category and commercial in the unmetered category.

2.6.4 INDUSTRIAL FACTORS

Smith (1985) detailed changes in industrial consumption in North West England for the period 1982-1984.

CATEGORY	MEASURED DEMAND CHANGE 1982-1984 (Ml/day)
FOOD DRINK & TOBACCO	-15.7
CHEMICALS	-25.4
ELECTRICAL ENGINEERING	-4.4
TEXTILES	-4.5
OTHERS	-9.2
TOTAL............	-59.2

Total measured demand relating to this data, in 1983, was 754 Ml/day.

Out of some 100000 metered customers 35% of consumption was accounted for by 100 customers. Much of the change in total metered demand was shown to be accounted for by changes in the top 100.

The same study also examined relationships between industrial consumption and site size.

Conclusions drawn were that typical commercial and light industries consumed water at a rate of 0.01 to 0.17 litres/second/hectare. Large water users tended to occupy large sites and have high rates of unit consumption. Each of the 38 top users consumed more than 0.1 litres/second/hectare. 30 of this group in-fact consumed more than 1 litre/second/hectare.

2.6.5 DOMESTIC SOCIO-ECONOMIC AND DEMOGRAPHIC FACTORS

From information published by Central Statistical Office, Park 1985, identified socio-economic factors affecting UK water demands. These included rising population levels, changing demographic factors, increasing standards of living and economic changes.

Two particular elements, considered to be of major significance with respect to water consumption, concerned;

1 The fall in average household size from 3.09 in 1961 to 2.64 in 1982. This fact is explained by an increase in one person households, a declining birth rate and a fall in households with six or more members and;

2 The increase in water using appliances, such as automatic washing machines, dishwashers and improvements in household ammenities.

2.6.6 HOUSEHOLD CONSUMPTION

Table 2.6 shows a breakdown of household water consumption, 1977-78, for South West England.

To present a wider flavour, figure 2.10 shows how UK per-capita consumption, for 1973 and 1983, compared to other european countries. Consumption varied from 105 l/person/day for Belgium to 264 l/person/day for Switzerland.

This provides a contrast with McLellon (1990), who reported that average North American consumption was taken as 560 l/person/day. Of this quantity, 400 litres per person is consumed within the house rather than the garden. Ishibashu (1991) suggested average daily Japanese per-capita water use of 230 litres, this, by inspection, compares to the top end of reported European consumption.

Assuming that household consumption accounts for 60% of combined urban/industrial use Smyth et al (1990) reportd that Australia's domestic consumption equated to 320 litres per person per day. 1985 household consumption in Jeddah, Saudi Arabia is detailed as 350 litres per person per day (Rizaiza 1991).

The figures above contrast with the OECD (1989) forecast, to the year 2000, per-capita saturation levels of 220 lhd for Sweden 260 lhd for Switzerland and 280 lhd, indoor use only, for the united States.

OECD (1989) also reported that domestic per-capita consumption split into three distinct bands for its member countries. The highest (USA, Canada, Switzerland and Australia) was a band in excess of 250 lhd. The report concluded that this level of consumption was due to a combination of garden irrigation (63% in Australia) and high standards of living.

It is important to note that reported household consumption may not include on-property leakage. This is particularly true in the UK where either internal metering or the summation of components has commonly provided the basis for whole house consumption. Both approaches have been in regular usage and both ignore the external buried pipework.

This element, which is termed the Service pipe, has recently been shown to account for water losses of 32 litres /property/ day, Goyal (1992). Growing evidence from this research and elsewhere in the UK indicates that this figure is a conservative assessment.

In its report based upon member countries OECD (1989) stated that: "All forecasters would be advised to make explicit the forecasts of leakage often implicitly included in public water supply predictions." The report suggested that by separating "leakage" from customer demand the background demand-supply gap could be better identified and appropriate solutions considered.

The results of a six year survey, Hooper 1985, provided an early relationship between consumption and a survey of household charecteristics. Per-capita consumption was found to be related to social class, represented by the following groups:

Class 1 Professional occupations
Class 2 Intermediate occupations
Class 3 Skilled, non-manual
Class 4 Skilled, manual
Class 5 Partly skilled
Class 6 Unskilled

Figure 2.11 shows per-capita consumption trends and variations across three groups 1, 2 and 3. From the same survey Table 2.7 provides analysis of growth in appliances between 1977 and 1983. The survey demonstrated the disproportionate usage of such appliances across the survey group. This fact was taken as accounting for the variations in consumption.

From evidence collected as a direct element of the Malvern and Mansfield studies Thackery et al (1978) it was concluded that: "average consumption in new housing is relatively high." This information was also pursued and confirmed from a separate study, on 50 new properties, the findings of which were also reported in "Malvern and Mansfield." Data presented in the report demonstrated that "average household consumption was 97.7 and 98.2 lhd in Malvern and Mansfield respectively. This compared to an average consumption for new properties, of similar size in the same geographic region, of 109 lhd.

In the report on social factors influencing water consumption (Pygall et al, 1978) the following comments upon upon the dissproprotionate effects of new housing stock (pp10) were made: "The results suggested that a 1% increase in housing stock was associated with a relatively larger increase, from 1.1 to 2.3% in unmetered water consumption."

2.6.7 CLIMATE

Whilst undertaking an analysis of whole system forecasting with respect to engineering considerations, Coulbeck et al (1985), determined that there was significant correlation between demand and temperature.

Bland (1985), commented that "peak demands were usually associated with hot, dry months and occasionally in winter months following long periods of very low temperatures".

Water Bulletin, 516 10 July 1992, reported that exceptionally hot weather together with early visitors had already caused demand to increase by 10% in Devon and Cornwall.

Garden watering is cited as the main cause of peak demands from May to September by (Bland 1985) particularly in drier eastern regions of England.

The individual effects of rainfall, temperature, soil moisture deficit and trade (to domestic) ratio were combined into a multiple linear regression equation (Carnell 1986). Individual examination of the variables revealed the following relationships:-

Increasing rainfall corresponded to decreasing peak ratios.

Increasing temperature corresponded to increasing peak ratios.

Increasing SMD corresponded to increasing peak ratios

Increasing trade ratio corresponded to decreasing peak ratios.

Temperature proved to be the most significant factor influencing the actual peak day ratio. SMD was taken to be more closely related to rainfall intensity than rainfall volume.

When considering effects of weather upon unmetered consumption Pygall et al (1978) concluded that "of the three variables representing climate, summer rainfall proved consistently the best, being the most likely to be significant and giving the highest values of Rsq."

Finally, with respect to UK climate, the Malvern and Mansfield Study, (Thackery et al, 1978) recognised the potential effects of climate upon household consumption. The survey was undertaken in May, June and July 1976, the drought year.

There was some evidence reported that measure invoked to combat the drought did affect household consumption. For example the data contained in table 6 of the study pointed out the discrepancy between household known to have hosepipes or sprinklers and the very small number of customers (5 and 6) who actually used them. In the subsequent discussion document it was stated that the reduction of 7% between 1976 and 1975 household consumptions was due to hosepipe restrictions. This aspect was expressed as a concern, relating to the studies findings, by several correspondents in the discussion document. It was further suggested, by R G Sharp pp488-489, that not only was 1976 an untypical year but that 1975 was also untypical. Therefore comparison between the two years was flawed in comparison to "normal" climatic conditions.

An interesting observation, during the discussion, was in relation to the declining trend of household consumption during the 10 week trial period. This was contrary to the drought conditions which were prevailing. The authors stated that "it seems plausible that in hotter weather the loss of body moisture through increasing perspiration could occasion a lower frequency of toilet flushing."

One of the reports findings was summed up in the statement that: "there is evidence to suggest that the overall average consumption during the 10 week (trial) period is similar to that of the winter/spring period." This contrasts to data submitted in the discussion for South West Water, that average consumption increase by 12% between March-April and June-July.

2.7 COMPARISON OF SURVEY AND ANALYSIS METHODOLOGIES

2.7.1 INTRODUCTION

The function of this literature review has been to examine the published work in the subject area, with a view to ensuring that this research complements and extends (rather than repeats) existing studies and to ensure that the findings of this research can be set in the context of previous results.

The final section of this literature review examines the survey and analysis methodological approaches which have been used in previous research. It is therefore intended to provide a benchmark for customer surveys and a framework for rigorous data analysis. Whilst strictly outside an examination of methodologies, summaries of associated relevant results have been included to provide relevant context and assist in determining strengths and weaknesses of the various methodologies.

2.7.2 ESTABLISHING DETERMINATES OF DEMAND

Schneider et al (1991), reported that numerous studies had been undertaken to investigate total municipal water use and an even larger number to examine residential water use. Relatively few studies have, however, examined demand using a dissagregated approach. Examples are Dziegielewski et al (1989) and Williams et al (1986). This fact is despite the trend of adopting dissagregated projections to build forecasts that are perceived to be inherently more realistic.

Schneider et al (1991) continued by deriving price elasticity for six categories of metered water consumption. These were:-

1. residential
2. commercial

3. industrial
4. government
5. schools
6. total

The analysis methodology adopted generated eight generalized least-square, linear regression models, composed of 5 causal variables. Schneider identified these as;

1. water price
2. income
3. population density
4. housing composition
5. precipitation.

The dependant variable remained as metered consumption, totaled for each community.

The conclusion was summarised as:
"that of the five independent variables water price had the most significant effect upon demand, in all user categories. However income, population density, housing composition and precipitation should be included in models for water demand forecasting".

The results of an analysis (Murdock et al, 1991) also indicated that sociodemographic and socioeconomic variables affect per capita residential consumption and could be important in predicting water demand. This is in contrast to the conventional across-the-board per capita forecasting approach expounded by, for example, Howe and Linaweaver (1971) and subsequently by an extensive body of identified researchers. (Consult Murdock, 1991) for detailed listing).

Suggested characteristics were:-

1. total numbers of housing units
2. proportion of minority groups in population
3. age of housing stock
4. extent of urban development and
5. the socioeconomic resources of population.

The conclusion was drawn from a study of 677 towns in Texas which included a 15 minute telephone survey of 800 addresses. The interviewee questioned respondents about water use, conservation, water costs, type and size of housing units and the use of water for bathing, washing clothes, dishes, toiletry, in hot baths and swimming pools, for lawn watering, for gardening and vehicle washing.

To assess the extent of multicollinearity among identified variables Murdoch et al (1991) adopted the procedure suggested by Gordon (1968).and computed inter-correlations accordingly. Each set of variables correlated at 0.6 or greater was subject to further analysis. This approach resulted in a reduction of 57 to 32 variables. The variance inflation factors were then computed for the 32 variables, after the procedure credited to Neter et al (1985).

The procedure involved regressing each independent variable with all other independent variables. The average variance inflation factor was determined for each variable across all regressions. High mean variance inflation factors (i.e. those greater than 1.0) were indicative of possible multicollinearity and should be investigated. Four more variableswere removed leaving 28.

The analysis indicated that "people residing in small households used nearly as much water as those living in large houses". Therefore, on aper capita basis it was possible to determine from the study that;residents of small houses used twice as much water as those in large houses. A summary of the conclusions was that this was due to more efficient use of appliances in large houses and lawn care and similar activities requiring similar amounts of water in either size property.

The study concluded that "demographic and other socioeconomic factors do affect water use and that their inclusion in projections of residential water use are likely to increase the accuracy of such projections".

Similar work was undertaken in Oklahoma and Tulsa (Cochran et al,1985). A model of municipal, residential, water consumption was constructed using the assumption that demand was a function of :-

1. price
2. per-capita income
3. precipitation
4. temperature
5. the number of households per unit of population.

The variables were studied individually using a least squares method. They were then collectively analysed using multiple linear regression,the maximum r2 technique and logarithmic regression. The results excluded all but per capita income as being statistically significant in both studies.

In a paper presented by Smith (1985), aspects of dissagregated metered demand were investigated for North West England. In common with the rest of the UK, metered demand covers elements of commercial agricultural and domestic consumption.

Smith reported that the majority of metered consumption reflected industrial usage. Table 2.15 represents an analysis of metered demand from Smiths work based on the 1969 Standard Industry Classification.

A general model was developed to aid forecasting of industrial consumption. This took the form of:-

Y = X + b (I) + b (P) + b (U) + E

where. Y = annual change in measured water

I = annual change in the index of manufacturing production

P = annual change in measured charges

U = annual change in unemployment

E = disturbance term

and x and b are constants

The unemployment variable was used as a surrogate which reflected changes in industrial structure and base.

Subsequent experience saw the model developed to the following:-

Y = x(x) x(E)

where Y = potable measured demand in year

X = index of manufacturing production in year

X = measured changes in year

E = disturbance term

The empirical result of this model was presented as:

$$\log Y = 1.84 + 0.63 \log X - 0.11 \log X$$

By virtue of being logarithmic the coefficients represent elasticities. Therefore a 1% increase in manufacturing output would cause a 0.6% increase in water demand. Similarly a 1% increase in water price would cause a reduction in demand of 0.11%.

Findings from the Malvern and Mansfield study (Thackray, 1978) were reported in section 2.5.6.2. The study is still frequently quoted within the UK water industry. A brief summary of survey and analysis methodologies employed are provided below.

During 1976 independent market research consultants liaised between Severn Trent Water and householders of two towns Malvern and Mansfield. At Malvern customers had been metered since the 19th century. At Mansfield meters were installed for the trial (Thackray et al, 1978).

The purpose of the study was to obtain basic data on components of household water consumption. To establish usage, cards were placed by each appliance for the customer to record frequency of appliance usage. Data was then obtained from manufacturers of, for example, washing machines to match water consumed to recorded programme cycles.

Data was analysed, using regression analysis on the days where no external usage was recorded. This enabled the volume of water used in baths, showers etc. to be assessed . The estimated volumes for these variables were then used to reduce unallocated consumption and hence provide a best estimate of external consumption.

Analysis was also undertaken on the frequency of appliance usage between homes of differing social background. This element of the study demonstrated marked differences between, for example, usage of baths and showers in private and council property. Further, the report commented upon the fact that the rate of bathing decreased, generally, with increasing household size.

Regressing average consumption within groups of similar rateable values followed a reasonable linear trend, explaining 63% of the consumption. However it was noted that dispersion was very great. General regression against a selection of variables explained 61% of consumption variation.

Classification by social class in Malvern showed a range of consumption from 76 lhd for class E to 126 lhd for class A.

2.7.3 CONSERVATION MODELS: CASE STUDIES

A number of classic case studies, external to the UK, exist. Five are reported in some detail in the following section to enable survey and analysis methodologies to be examined against the context of this research. As explained in section 2.7.1, summarised results, findings and opinions for the 5 case studies are included for completeness.

REFERENCE MODEL 1. RESIDENTIAL WATER CONSERVATION

Having undertaken a review of relevant literature Bruvold et al (1988) used the information to construct a predictive model combining four conservation measures and four exogeneous variables.

The dependant variable was selected as estimated residential per-capita consumption. The adapted conceptual model is shown as table 2.8 and has 5 components.

Conservation measures were assumed to impact upon demand through knowledge variables which controlled customer response. In addition account was taken of exogeneous variables, which may also have influenced control over the dependant variable. Two of these variables were socioeconomic; income and house size, and two were climatic; temperature and rainfall.

The model assumed that behavioural responses would manifest themselves by customers, for example, taking shorter showers or reducing garden watering frequency. Structural responses included the use of physically restrictive measures, i.e. toilet dams etc., to limit water use. These behavioural variables would be determined by the customers beliefs and knowledge variables such as; amount of water normally consumed in the house and in the garden and views on the need for conservation.

A cross sectional customer survey provided information for the model which took the form :-

PCDU = f (KU, CB, MP, RS, MT, NH, HI)

where: PCDU = per-capita consumption

KU = knowledge of use coded as a binary variable (0=no knowledge, 1= knowledge)

CB = conservation belief score ranging from a low of 20 to a high of 100 points.

MP = marginal pricing for the major block of residential consumption.

RS = rate structure.

MT = mean temperature.

HS = household size.

HT = household income.

Analysis of the survey results indicated that most respondents were in favour of conservation measures but that a maximum of 40% were aware of their own water consumption levels.

Increasing temperature and income were each shown to be strongly related to increasing consumption. Water price, precipitation and increasing family size related to lower per-capita consumption. The knowledge variable was positively related to the model but the belief variable was not significant.

Bruvold concluded that "the application of an aggressive increasing block rate structure and vigorous education programme would create a synergistic effect upon demand".

<u>REFERENCE MODEL 2. RETROFITTING INDOOR APPLIANCES</u>

The demand for water, even by a single household, is a function of multiple variables. Attempting to establish the impact upon demand through the application of physical measures can therefore be complex. Whitcomb (1990) recognised this as a problem and applied a multivariate control group approach to deal with such difficulties.

The adopted methodology compared water use between "test" households, to which conservation devices had been fitted, and control groups. Differences in water use were accounted for by explanatory variables. A winter period was used to obtain results as this excluded garden watering.

The model defined consumption as a function of household occupants, income, method of bill payment and conservation fittings status and took the form:-

```
WATER =  a*PER * (1 + b*CHILD + c*TEEN + d*SENIOR)
         * (1 + e*LOWINC + f*HIGHINC) * (1 + g*WATERBILL)
         * (1 + h*LOWSHOWER + J*TOILETBAG) + RESIDUAL
```

WHERE The nine lower case letters are coefficients to be estimated, and for each individual household:-

WATER = daily water use
PER = number of occupants
CHILD = percentage of occupants under 9
TEEN = percentage between 10 and 19
SENIOR =percentage over 65
LOWINC =1 if household income < $20000; otherwise 0
HIGHINC=1 if household income > $60000: otherwise 0
WATERBILL=1 if occupants are not billed
directly 1; otherwise 0
LOWSHOWER=weighted percentage of showerheads that are
low-flow
TOILETBAG=weighted percentage of toilets with toilet bags
RESIDUAL =residual term.

The model was thus set for adults between 20 and 64, income between $20000 and $60000, bills paid directly, ordinary showerheads and conventional toilets. In such a case all variables other than daily water use would be zero. The coefficients would be greater than zero if the variable it represented caused an increase in per-capita use.

The underlying premise of this model was, that the adjustment variables proportionately change water use. This contrasts with summation models that assume absolute changes in water use. For example if water use varied with a persons age then it is likely that the magnitude of savings from conservation devices would vary correspondingly, i.e. greater savings would be estimated for higher consumers.

Demographic and fixtures information was obtained from a telephone survey of a random sample of properties in two areas. Complete data sets from 308 properties were obtained. There was a 15% refusal rate concerning the questions to determine income.

Table's 2.9 and 2.10 present the mean variable values of surveyed households and the model results respectively. Whitcomb 1990, concluded that occupants age and high household income exerted the most influenceon per-capita demand. Estimates of percentage savings generated by the model are converted into volumetric savings in Table 2.11. Complete installation of low-flow showerheads and toilet bags was predicted to reduce consumption by 6.4% and 2.1% respectively.

<u>REFERENCE MODEL 3. A CONTINGENT VALUATION APPROACH</u>

A study (Thomas et al, 1988) provided two very interesting methodologies developed and applied for survey and analysis of household water demand in Perth, Australia.

The study considered that "analysis of residential demand by econometric methods could be flawed". It was reported that estimates so generated can suffer when colinearity, non-stationarity, changes in price structure or unclear identification of either the exogeneous or endogeneous variables occur

The research adopted a contingent valuation approach for just such an eventuality and compared results from the same study analysed using multivariate techniques.

Contingent valuation techniques use surveys asking customers to state their likely reactions to, for example, price increases.

The technique is sensitive to influence by knowledge and attitudes adopted by either the respondent or interviewer. However the same holds true for most interview or questionnaire approaches and merely serves to highlight the importance of survey design to obtain an accurate data set.

Components of water use were taken to be; kitchen, bathroom, toilets, laundry, irrigation and other outdoor use. The contingent valuation investigation obtained, for each household: Basic demographics and appliance ownership, estimated external and internal water use and estimated effects of changes to family composition, appliance ownership and garden use. Annual consumption data was obtained by reference to utility records.

During the survey stage two household members were asked to be present. Normally husband and wife. The second respondent became a critical and informed observer removing elements of incorrect or fanciful response. The questionnaire was designed as an advisory service and it was considered likely that such an approach would be much more effective in ensuring customers subsequently applied conservation knowledge to their households.

Table 2.12 and Figure 2.12 illustrate evaluated components of water useand a schematic survey flow chart adapted from the study.. A list of water saving measures applicable to households is also presented as table 2.13.

Results of the contingent valuation approach indicated a price elasticity of -0.2. Households having lower price elasticities included those with private wells, small volume consumers and high income groups. Econometric analysis, using regression techniques, indicated price elasticities ranging from -0.1 to -0.43.

The research concluded that "contingent valuation is a feasible approach particularly when trying to estimate changes without time series data. Further, only basic information or even substitutes for indoor/outdoor water usage are required". The detail collected in this study proved unnecessary.

The concerns expressed over poor knowledge of endogeneous and exogeneous information, which led to the identification of the need for a contingent valuation approach, were particularly centred upon water price. For this reason I chose to treat price change as a relative measure (% increase or decrease) in the contingent valuation approach adopted for metered customers detailed in chapters 8 and 9.

REFERENCE MODEL 4. RATE STRUCTURE.

Agthe et al (1988) reported results from a survey designed to establish the effects of rate structure on household water use. In contrast to the contingent valuation theory, regression techniques were employed for analysis. However, since since all households were subject to identical rates, price as an independent variable was omitted thus removing the variable which had caused Thomas et al (1988) most concern.

A linear cross section demand model was developed to determine socioeconomic influence on consumption:-

$$Q = bT + DbT + bO + DbO + bL + DbL + bS + DbS + bH + DbH + bI + DbI + e$$

where; Q = water use per month
T = length of tenancy
O = ownership 1=own 0=rent
L =landscape 1=arid 0= humid
S = swimming pool 1=yes 0=no
H = household density
I = income 1= < $ 10000 2=> 10000 but <20000 etc
D = dummy variable 1= informed 2 = uninformed
e = regression error
b = regression coefficients

The demand model supported beliefs that variables influencing consumption differ between winter and summer periods and between customers who are knowledgable about rate structure and those who are not. The study identified for example the lack of information about the potentially 'penalising' increasing block rate structure shown on water bills.

REFERENCE MODEL 5.
A DISSAGREGATED APPROACH: THE IWR-MAIN MODEL

In establishing a principle for modelling American water demand (Howe et al, 1967), identified only two input variables: water price and housing value. The approach was reviewed by Howe (1982) but Dziegielewski et al (1989) adopted and extended the principle to create an algorithm which forms the basis of the IWR-MAIN (Institute for Water Resources Municipal And Industrial Needs) computer model. The design of this model relied upon the disagregation of urban water use into as many as 280 categories (SIC codes). Factors that were assumed to determine both the need for and intensity of water demand were then constructed for each category. Total requirements were analysed by summating each element with respect to time.

In the residential category, factors adopted to forecast intensity of use were:-

Income; which measured the consumers ability to pay for water.

Conservation Behaviour; which reflects the consumers willingness to substitute inconvenience or technological innovations for water: and

Price; which determines the amount of water a consumer is willing to pay for.

The basic model then took the form:-

$$A = f(P,V,H,W,C,N,E)$$

where: Q = average daily water use in year

and, P = price of water.
V = market value of housing units, in bands.
H = number of persons per housing unit, in bands.
W = weather conditions or climate (in residential categories)
C = conservation programs.
N = numbers of users. and
E = number of employees (in nonresidential categories).

Once estimates of water use in individual categories have been computed, total water use is obtained by summation of all elements of consumption.

Residential water use is estimated using equations that utilize a combination of price, income and the stock, per residence of water-using appliances, household size and weather conditions. In practice the housing unit-value is used as a surrogate for income and water using appliances.

Non-residential uses are disaggregated into as many as 280 categories split into the three major sectors; industrial (manufacturing), commercial/industrial and public/unattended. Average water requirements are determined on the basis of water use per employee per day.

Since the intensity of water use in all sectors can be affected by water conservation measures, the model contains a procedure for estimating the effectiveness of up to 18 conservation measures. 14 of which have been defined as:-

1) public information/education
2) metering
3) reduction of system pressure
4) water rate policy changes
5) rationing
6) sprinkler restrictions
7) industrial recycling
8) commercial recycling
9) leak detection and repair policy
10) retrofitting to toilets and showers
11) moderate plumbing code compliance
12) advanced plumbing code compliance
13) low-water use landscapes new construction and
14) low-water use landscape retrofit

The impacts of conservation measures are calculated by considering; estimates of water reduction achieved through conservation measures, market penetration of measures and the anticipated interaction between multiple conservation practices. A formula was then created to generate a factor for consumption adjustment based upon a range of selected conservation elements.

A number of factors had to be generated outside the model. These include population, employment and household income or its surrogate for each year of forecast.

The application of the IWR-MAIN model was severely criticised in a subsequent article (Wilson et al, 1990). Attention was drawn to the degreeof complexity attracted by up to 280 nonresidential categories. This creates 5600 input values for a 50 year forecast. The paper contrasts this degree of input, which governs normally less than half of total consumption, with the "simplistic" approach to residential consumption.

Errors were compounded by "unrealistic" estimates of increasing residential values and non application of weather adjustments for residential use in an arid region. Further, in the example the model had assigned, for example, public parks with office blocks and golf courses with art gallery; yet separated dance studios into a unique group.

Whilst agreeing with the model methodology the critique concludes that:

"there seems little point in using such a complex system; a modified per-capita method which divides out residential and commercial uses, and which is based on explicit assumptions about matters such as price and price-elasticity, will serve just as well."

2.8 DISCUSSION OF LITERATURE REVIEW

2.8.1 INTRODUCTION

The UK Water Industry embraces numerous services. Certain elements impact daily upon all customers, for example water supply and sewerage services. Yet other elements are remote from the customer such as water resource and environmental protection. There is however an undeniable link between the two. Whilst customers, in general, expect their specific needs to be fulfilled, i.e. a safe and sufficient supply upon demand. There is also a general expectation that "the environment should be preserved".

Herrington (1990), summarised the dichotomy in his statement that "at times the public will appear to double up uncomfortably in their roles of water customers (low charges desired) and friends of the environment (more protection means higher charges)". The intention of this research is to assist in further determining how such potentially opposing requirements can be satisfied.

This section summarises and discusses the salient points and referencesfrom the literature review to assist with the subsequent construction of objectives and hypotheses, in Chapter 3. Generally, any references or summaries of references from earlier sections are not referenced again.

2.8.2 CUSTOMER NEEDS AND PERCEPTION OF WATER SUPPLY.

Management of water resource has become a focus of increasing public scrutiny. This fact has arisen due to a higher profile being attached to the UK water industry in recent years.

The starting point was most probably water industry reorganisation in 1974. Specifically the consequent separation of water bills, from general rate demands. Subsequent droughts, the water strike, privatisation, abolition of rateable value and metering trials have continued to maintain media and public interest at a high pitch.

Due, in part to its climate, North America has been subject to the need, to control water demand, for much longer than the UK. Consequently the USA, in particular, proved to be a major source of review material.

Individuals residing in those communities with the luxury of piped supplies, tend to exceed the level of basic water need many times over. In general this becomes the 'norm' and supplies get taken for granted. Such customers typically devote approximately 0.5 to 1% of household income on reliable and convenient water supplies. Individuals in low-income countries typically spend 3 to 5% of their income on water which may be of lesser quality and questionable reliability.

To meet basic needs, individuals are willing to pay up to 120 times more for water from a vendor than the equivalent cost from piped supplies available elsewhere in the same community. This is despite the very real health risks associated with purchasing potentially contaminated water from a unknown source.

Application of Maslow's Theory of Hierachical Needs provides an explanation of this point. Primaeval instincts to satisfy immediate basic needs are of paramount importance. Not until 'comfort levels' have been achieved, and are sustainable, will individuals broaden their horizons to consider 'nonessential' factors. In this context nonessential would include water above basic needs, disposal of sewage and protection of the environment.

In developed communities, customers are prepared to purchase bottled water even when there is a plentiful supply of piped water. The reasons for such 'extravagant' purchases hinge upon concerns over the quality of tap water coupled with effective marketing strategy. Whatever the reasons, purchase of bottled water serves to demonstrate the product's price-elasticity even outside of crisis.

In fact as a fundamental requirement for sustaining life itself, individuals would give everything for the 'last drop' of water. In theory therefore, at very low volumes, water has a zero price-elasticity. In normal circumstances the abundance of water means that its market price is low and therefore users experience a large consumer surplus from its purchase.

The range of reported daily per-capita water consumption, 105 to in excess of 560 litres, reflects the spectrum of international variation. This is readily placed in context when compared with the still comfortable per-capita basic needs requirement of 20 litres/day (Chandler,1990) Such a comparison emphasises the extent to which accepted consumption exceeds minimum requirements.

The purpose of this research is not to identify basic needs and drive consumption down to such a level. The stated aims are to establish variables influencing overall consumption. Consideration of extremes does, however, serve to illustrate the potential for conservation, if and when required, using techniques collectively referred to as Demand Management.

A view is provided by Herrington (1990) whilst considering UK service standards. The suggestion is offered that: "examining the cost-benefit analysis of demand restriction rather than the more usual service standard enhancement", may be an option available to the water industry.

2.8.3 DEMAND MANAGEMENT OPTIONS.

Four options were identified for consideration. Two of these, in the UK, are subject to the Director Generals 'Levels of Service indicators' on Water Usage Restrictions. As a consequence typical return intervals of between 10 and 100 years have been adopted as desirable for voluntary appeals (education) and mandatory 'drought order' (regulatory) provisions respectively. Both measures can produce substantial reductions in demand: 3 to 25 % for voluntary appeals and up to almost 100% reduction for severe legislative bans, such as the imposition of street standpipes.

Such measures can therefore be seen to be very effective if correctly 'sold' to customers. However voluntary savings tend to diminish with exposure and levels of reduction are unpredictable. In addition the costs of ensuring the customer gets the message, which requires frequent repetition, can be high. Both voluntary and legislative measures(drought orders) are excellent crisis management tools but are not acceptable as sustainable measures.

The two remaining demand management measures can be used independently, or, for greater effect, together. They are the application of operational control, to deliberately slow demand, or the imposition of pricing measures to alter price-elasticity and hence invoke additional supply and demand potential.

For the purposes of this research, pricing measures have been interpreted as a direct relationship between payment and recorded quantities, or a surrogate, of water consumed. Thus fines imposed for example on unlicensed hosepipe usage are considered as legislative, and normally, linked to crisis measures rather than deliberate and planned demand management.

In the UK most households are not metered. Information relating to influence upon consumption is therefore limited. The Water Industry and DoE jointly sponsored a trial, commencing in 1988, to determine the effects of metering including measurement of "average" household consumption.

The same trials also saw tariff experiments introduced to measure behavioural modification when consumers were exposed to nonstandard charging schemes. This was particularly true of tariffs incorporating low standing charges thus making customer bills sensitive to volume consumed.

Results of the trials have been encouraging. System demand in the Isle Of Wight reduced by 10 to 20%. Unfortunately because customers were not independently measured, before being charged by meter, a true control comparison is not available. The estimated savings are based on whole community demand measured as gross system input.

The National Consumer Council (NCC) have criticised trial results as 'misleading'. Claiming that much of the savings resulted from leakage which was repaired as a consequence of meter installation. The NCC argued that a programme of leakage detection and repair carried out with similar intensity would produce much of the savings at a fraction of the cost.

In other countries, particularly North America, significant reductions in individual customer consumption have been recorded due to volume charging schemes. Typical savings have been in the order of 25% , but 45% has been achieved.

Consumption in these countries is much greater than the UK. Hence the scope for savings is also greater. This statement is particularly pertinent when the high proportion of nonessential water use and particularly irrigation, is taken into consideration.

The case studies demonstrated that savings can be achieved through a combination of voluntary restrictions, linked to education. For example watering the garden for shorter periods or the use of water efficient appliances.

The fact that many activities waste unnecessary quantities of water is recognised. Appliances such as Low-flush toilets and water efficient clothes washers are available. In the UK and North America 'codes of practice' are being modified to introduce low usage equipment.

This is fine for newly installed equipment but most water will continue to be consumed via existing appliances. The voluntary replacement rate of, for example, toilets is low. Once installed, with minimal maintenance, they will last a very long time.

An alternative is to retrofit equipment to existing appliances. Sufficient scope exists to reduce unit water consumption whilst maintaining standards of service. Programmes to conserve water using such techniques have become very successful particularly in the USA.

Retrofitting of toilets, shower heads and taps can produce worthwhile savings. Individually, toilets provide the most significant target due to the frequency of use and consequent savings that can be achieved. Costs to supply toilet dams, low flow shower heads and low usage taps are estimated at $80 per household (1991 prices). North American experiences indicate overall household savings, using all of this equipment, of up to 30% when combined with for example, penalising rising block rate structures. Used independently the use of retrofit devices would have an expectation of achieving 8 to 15% savings in America.

Having supplied the equipment it must then not only be fitted but also fitted correctly. This can be achieved by either educating the customer or arranging to undertake the work directly. Each option carries a cost and selection is normally decided upon by the merits of scheme requirements. Installation by customer will normally entail lower costs but produce fewer installations and hence reduce the effectiveness of potential conservation.

Retrofitting or replacing equipment, as described, will allow many appliances and practices to continue to consume water in an unmodified manner. At times of crisis, supplying daily peak demand may be the problem. The review indicated that such peaks often occurred due to climatic effects upon customer behaviour. It is unlikely that instantaneous peaks are caused by a substantial increase in, for example, only toilet flushing. More likely is an increase in consumption from a combination or range of activities such as a general increase in the use of baths and showers, drinking, garden watering, clothes washing and car cleaning.

Whole property 'influencing' will affect all activities. Pressure control, by reducing distribution system pressures, directly relates to flow and has been proven to reduce household consumption by 3 to 6% in the USA.

Systematic pressure reduction is normally approached through the control of a widespread area with reference to a critical point. Within a discrete geographic zone such an identified location is used as a minimum standard of service indicator. Due to topographical and system characteristic variables, properties away from the critical point will, by default, enjoy higher standards of service. Technological advances allow fine tuning of pressure control systems to meet continuous variations. Correctly designed pressure control systems can be self financing in a very short period. They require devices at very few locations to control supplies to large areas.

Greater control can be exercised by reducing district size and hence limiting variation. Ultimate responsiveness can therefore be achieved by controlling each properties pressure with an individual device. This is indeed possible and provided the starting point of this research.

Property specific installation presents the opportunity to fine control distribution delivery. In addition, individual customers requiring standards of service outside of normal specification can, within practical limits, so choose.

Installation of controls at customers property provides three options. The first is to enable a specific balance to be achieved between distribution system characteristics, property characteristics, and customer requirements. The second is to stimulate conservation and the third is to provide a potential mechanism linked to charging regimes.

Herrington (1990) alludes to such a possibility by stating that "there may be an incentive for private water companies to maintain universal standards as low as possible (the revenue from them will be controlled by price regulation) and then offer customers gold-star or premium service outside the basket of services subject to tariff control".

From the review it was identified that customers in general, but particularly households, consume water substantially in excess of minimum needs. It was also established that customers expect environmental protection to be an integral element of water resource management. Further it was shown that reduced consumption can occur, without detriment to customers. Finally, in this respect, customers want a satisfactory service at lowest prices.

2.8.4 METHODOLOGICAL APPROACHES

A number of key methodological approaches were reported in detail. They were selected to represented preceding work which influenced the direction of this research. Details of their subsequent usage as guides and signposts are included in section 3.3.

Two approaches were described: econometric analysis, normally utilising linear or multiple regression techniques, and contingent valuation. The latter was originally utilised to avoid "flawed econometric" methods. It was argued that observable flaws appeared to be generated by "poor knowledge" centred upon water prices.

The application of regression techniques provided modelling flexibility with explanations being generated for between 40 to 65% of cases. Methodologies for checking on flaws within models were identified by Murdock and Neter in Section 2.7. Both practices were employed to prosecute this research.

A number of causal variable were identified and tested. Schneider determined that water price was the most significant in his work (2.7.2). Murdock identified that "demographic and other socioeconomic factors" affect water consumption. He was thus able to explain why small houses often accounted for similar water consumption to large houses. Bruvold provided evidence linking increasing temperature and customers income to increasing consumption and, conversely, increasing water price, precipitation and larger family units to lower per capita values of water consumption (2.7.3).

Whitcomb (2.7.3) identified that occupants age and household income had the greatest impact upon consumption. The study demonstrated savings of between 2 and 6% for low flow apparatus fitted to showers and toilets.

Agthe et al (2.7.3) demonstrated a model fitting consumption to several socioeconomic factors. In particular income and housing density. However the study was principally concerned with charging rate structure and its impact upon consumption. The study concluded that rate structures can be tailored to influence consumption. In practice, however, despite substantial educational initiatives the lack of understanding of scheme information caused customers to abuse conservation objectives.

The final case study represented what may be regarded as the ultimate in a dissagregated approach to forecasting, model 5 (2.7.3). The summation of the 280plus variables into approximately 25 "types" and the model construction proved instrumental in early isolation and catergorisation of variables and analysis. However detailed criticism of the model indicated that the approach, whilst fundamentally sound, was overly complex and flawed by a few inappropriate customer groupings.

2.8.5 SUMMARY

This literature review has considered a range of studies their results and their methodologies in the area of demand management. It has therefore provided the context for the hypotheses which are developed in this research and some options for investigating and testing these hypotheses. The refining of hypotheses and methodologies are considered in the next chapter.

PART TWO

DEVELOPMENT OF RESEARCH

OBJECTIVES AND HYPOTHESIS

CHAPTER 3

DEVELOPMENT OF RESEARCH HYPOTHESES

3.0 OUTLINE OF RESEARCH ISSUES

The fundamental concern of this research project is that demand for water can be managed to the benefit and satisfaction of both water undertakings and their customers.

Central to this concept is the view that on-property consumption can in-fact be influenced, whilst maintaining (UK) regulatory requirements and satisfying customer demands. The degree of excess water consumption, between available and potential standards of supply, provides the scope for conservation or an equitable supply regime.

In practice the research has not been able to examine all aspects of demand management but a number of key elements have been investigated.

Demand management is an often used term in the UK but, unlike elsewhere in the world, very few serious attempts have been attempted in this country. Notable exceptions have been droughts, particularly 1975/76, the water industry strike and, increasingly frequent, regulation through hose pipe bans. These are examples of "crisis" management applications of demand management, cheap and cheerful, but effective solutions when demand threatens to outstrip supply in the short term.

This research project has attempted to provide a much more generally valid approach and application of demand management to a UK water supply system.

The term "demand management" is interpreted in this research as the attempt to regulate or influence customer consumption to achieve preset objectives. It is unusual to use demand management to increase consumption but this could well be a valid requirement. Demand management is aset of methods that allow the balancing of supply with customer requirements.

Demand Management can be implemented to achieve different levels of water balance :-

a. The reduction of peak demand
b. The reduction of average demand
c. The suppression of any consumption above basic needs.

In practice the separation of peak or average demand management becomes blurred. Customers use water in different ways and at differing intervals. What may reduce peak demand for one customer could readily impact upon average elsewhere. For the purpose of this research it is my intention to examine the effects of a trial to modify customer consumption whilst maintaining standards of service and hence continue to satisfy customers water requirements.

3.1 EMERGENCE OF ISSUES FROM LITERATURE REVIEW

The study examines the advantages for both customer and company of such an approach. Can the water company benefit from lower operating costs? Savings might be due to immediate reductions in supplying to meet peak demand or longer term deferments of additional resource development. This would provide the operator with the opportunity to pass through any cost savings to the customer and meet customer expectations concerning environmental care.

In reality the high proportion of fixed, scheme installation, costs may force substantive savings to the long term, i.e. deferment of capital expenditure. There may still, however, be benefits to be shared: Conservation on an environmental scale and achieving greater stability of supply by ironing out, for example, demand peaks and troughs. The study will investigate aspects of benefit to customer and company.

Ideally, if a customer requires a differing level of service he retains the right to upgrade or diminish his personnel standard of service, subject to application of an associated cost. For example customers who directly influence their water bill, i.e. metered customers, can deliberately choose to consume more or less water and pay a corresponding sum. The customer has tailored consumption to meet his needs. This may be dictated by an industrial process, gardening requirements or the number of people using a specific property. In each case however the customer can exert influence. Water using appliances can be selected for their "water economy", showers consume less than baths, and gardens can flourish with less water. In the UK the majority of household customers pay for water via "direct charges", section 2.4.2. Such customers are not presented with any incentive to control water consumption.

In cases where demand management is achieved through 'physical' (operational control) measures then the 'cost' of consequent reduced revenue income must be further weighed against costs of fixing 'restrictive' apparatus. Further, achieving widespread management of demand through the application of physical measures can only be regarded as a long-term option. The sheer practicalities of installing equipment will not allow short term conservation to be achieved.

For the purposes of this study all methods capable of realizing sustainable savings, including metering, are considered as 'demand management'!

This research is however particularly concerned with consumption of water on-property. In this respect both flow and pressure are important: Controlling district pressures is likely to modify on-property pressure and hence consumption. Limited evidence indicates that reduction of district pressures might yield on-property water savings of between 3 and 6%, section 2.5.5.7.

Tracing leakage within a district is likely to reveal some on-property losses which can be brought to the occupiers attention for repair.

The author is of the opinion that the point of optimum control presents itself at customer boundaries. Thus provision specific to that property can be obtained without disturbance from upstream demands or requirements.

For example consider an area containing a mix of households and commercial business. The community is also host to one large industrial consumer. Conventionally the system would have been designed to ensure adequate supplies to this one property. In general all other customers would have been supplied with a standard of service considerably exceeding minimum. Without substantial, and costly, system modification little could have been achieved to conserve water through the application of system pressure reduction.

Whilst customer expectations of standards of service were being met, and considerably exceeded, a number of hidden issues were occurring. First and foremost, customer expectations of conservation were not being achieved. Artificially high standards of service were creating unnecessary consumption by the majority of customers and increased leakage on the system.

In turn, unnecessary costs would have been incurred and eventually borne by the wider customer base. At extremes, system flows and pressures, maintained to meet the single industrial customers demand, could have resulted in complaints of high pressure.

Large draw-offs by the industrial user would have a negative effect on the community by reducing pressures in the distribution system. At certain locations, i.e. high contour points, this would manifest itself by causing loss or reduction in supply to households. A secondary, consequential, effect, likely to cause additional complaints, is that disturbances to steady flow conditions may create severe discolouration. This could easily be bled-off, through customer taps, when normal household draw-off took place.

The above example serves merely to demonstrate system inter-relationships and the potential effects which could directly affect customers when applying a broad regional system control to an area of mixed consumers.

A similar scenario can occur in areas of single category consumers, i.e. households, when the location comprises either significant variation in contour levels or particular discrimination as a result of distribution characteristics. Thus customers living at the base of a hill or a point of 'distribution plenty' can be in receipt of a service substantially in excess of their neighbours. The introduction of control at, for example, customers property boundaries would smooth this element of random or historic discrimination and establish a degree of equality.

This approach does not ignore either district control, adherence to regulations or point of use conservation but should be considered as complementary. Each has a place in the sensible usage of water but the application of more than one approach may stimulate multiples, or additional savings.

No evidence has been forthcoming on the influence such an approach may yield when specifically applied to complete properties. Techniques designed to stimulate savings downstream of application are available, for example miniature pressure control devices. The review confirmed a need to undertake research into such an application.

3.2 WATER INDUSTRY CONCERNS

The implication of influencing customer supplies is likely to be perceived as a threat to standards-of-service in order to maximise utility performance. Despite press comment to the contrary, responsible water utilities are in fact very concerned to ensure adequate supplies to customers and, for example, South Staffs Water has always been of this persuasion. With the advent of regulatory control, as discussed in Chapter One, a very active, vocal and independent body now also sits in judgement on adequacy, thus providing increased security and enforced conformity.

In the interests of protecting the customer, South Staffs Water apply internal policies to exceed Director General Service Standard requirements, nominally by 50%. Thus targeted minimum flows and pressures are 15 litres/minute and 15 metres head respectively.

The elaboration of this aspect was considered worthwhile to reassure readers that achieving unacceptable standards-of-service was not the objective of this research. Nor indeed is such an objective tenable given regulatory requirements. However a principal objective of the Regulator is to promote efficiency and avoid discrimination concerning both customer standards-of-service and charges.

The Regulator's duties may be better achieved, by the Water Industry,through a greater understanding of the variables influencing consumption, whether arbitrary or imposed. Further, the potential to provide a measure of supply equity may reduce discrimination even within classes of consumer groups.

Having examined and established the potential and logic for influencing consumption, two specific market sectors presented themselves for research application. These were:-

1) Households and
2) Metered customers,i.e. those already responsive to charges applied by volume.

The two categories represent parallel charging schemes commonly maintained by the UK water industry to collect unmeasured and measured water rates. The data in each set includes elements of overlap i.e. unmetered commercials and metered households. The data set for South Staffordshire Water is represented as:-

SOUTH STAFFS WATER DETAILS OF CUSTOMER CHARGING BASE

	@1991
UN-METERED HOUSEHOLD	471000
METERED HOUSEHOLD	14000
UN-METERED COMMERCIAL	13800
METERED COMMERCIAL	16000
TOTAL.............	514800

In subsequent discussion customers groups are generally referred to as either household or trade (or industrial) customers with the later expression referring to metered customers.

Reearch at South Staffs Water was conducted over the period 1985 to 1992. Thus, at its inception households, were charged by rateable value, unless the option to be metered had been exercised by individual customers. The question of 'universal metering' as an alternative to the rateable value approach was being raised, witness the 'Watts Report' of December 1985, but water industry policy, with respect to charging, was undecided.

3.3 ESTABLISHING THE KEY RESEARCH QUESTIONS.

The original concept was developed whilst considering two requirements, these were;

1) the control of demand in a predictable manner and

2) the provision of an equitable charging mechanism to replace rateable value whilst offering an alternative or extension to metering.

The research evolved principally around the control of demand, for the following reasons;

1) It was considered desirable to establish a reliable demand management control before offering it for consideration as an equitable charging tool capable of widespread acceptance.

2) In 1985/86 there was uncertainty concerning what form the future, imposed, basis for charges would take. Alternatives to metering were available and if, for example, retention of the rateable value mechanism was permitted then the industry would not necessarily be seeking alternatives.

3) No suitable legislation existed prior to 1988 for the imposition of charging mechanisms other than rateable value or meter options. It would therefore have been problematical to impose alternative charging mechanisms on an unbiased sample (although this possibility was initially investigated).

4) The development of a reliable, predictable, property specific control mechanism had the potential to also provide the function of an alternative tariff mechanism to be used in conjunction with, or without, a conventional metered supply.

5) The potential conservation advantages from understanding factors influencing consumption were likely to be high in their own right.

6) In addition controlling demand and equalizing potential consumption whilst maintaining customer standards-of-service had the potential to meet customer, regulatory and industry approval.

As identified, in section 1.2, the water industry continues to invest many millions of pounds in its infrastructure, £2,245M in 1990/91 only. As at the 31st March 1991 the total UK water industry fixed assets were valued at £133,520M ,CRI (1990/91). At South Staffordshire Water PLC the two comparable figures were £5.96M and £650M respectively.

Much of the asset costs go towards meeting occasional peak demands experienced as a result of combinations of exogeneous and endogeneous variables.

For the year 1991/1992 peak day to annualised average ratios for South Staffordshire Water were 1.25 : 1. This ratio increases as the number of connections diminishes. A single connection could theoretically yield a ratio of 100:1 or more. In practice physical restrictions, imposed by plumbing and aging, tend to reduce the available potential for peak flow.

Within an established property, excess water, available at the boundary, is often not sustainable at the point of use. The terminology "demand" is therefore not correct. Customers can only receive supplies to the upper limits of their plumbing systems capacity.

The fact of meeting individual customer demand is exacerbated by the cumulative effects of simultaneous draw-off. This effect ranges from the interaction of numerous properties served by a single small bore service (shared supplies) through to entire communities vying for limited supplies from a distribution network at its limits, section 3.4.1.1.

At the extremes of any influencing variables, customers may be subject to imposed limits or restrictions. In practice this may be on a Sunday morning when, household generated, system peaks normally occur. Alternatively it may be during hot or cold periods which cause gross alterations in either behaviour, system characteristics or both.

The interaction of such influences tends to occur on a "random basis". For example customers within a finite geographical area will have supplies which can be modified not only by the action of their neighbour but also the local topography and numerous other determinates.

The combined effects dictate maximum quantities of water available to the customer at his individual point-of-use.

Generally customers will not be aware of "modifications". Attitudes and expectations have traditionally been geared towards the standard-of -service available. There is, for example, anecdotal evidence that customers, particularly in isolated or remote locations, keep baths full to supplement poor supplies; often without comment to the water utility concerned.

The research assumes that if the "imposed" non-policy restrictions and inter-relationships were removed then demand, particularly by customers at extremes, would increase. This implies that customers absorb and accept modifications to available water supplies even to extremes.

Such a consideration supports the generalisation that variations in demand are dampened, by arbitrarily occurring system characteristics, without the customer necessarily being aware or adversely reacting.

The notional measure of an adverse reaction is, for the purposes of this research, taken as: registering a complaint with the water utility.

Customer consumption is therefore subject to "naturally" occurring modification. In practice considerable variation exists even between properties of apparently similar characteristics subject to similar standards-of-service

The development of this research can now be progressed, linked to thefollowing questions :-

1) Can consumption be deliberately modified, whilst maintaining standards-of-service ?

2) could water resource be conserved ?
(thus offering similar justification used to promote the financing of water metering)

3) would the equalisation of available levels-of-service yield benefits to the customer, utility or both ?

These questions provided the starting point for this research. In order to provide answers it is essential to explore in detail the full range of variables which might be expected to influence consumption. In the course of this discussion hypotheses will be developed which will allow an explicit testing of the role of each variable in determining water consumption at South Staffordshire Water. The developed hypotheses are summarised in Section 3.6 for convenience.

3.4 VARIABLES EXPECTED TO INFLUENCE WATER CONSUMPTION

From sources detailed in the Literature Review it is recognised that consumption varies not only across classes of customer but also within nominally similar groups. This section examines the variables potentially explaining why variations in consumption occur. They are a combination of exogenous and endogenous factors with the common attribute of potentially influencing on-property demand for water. Four broad areas were identified to represent impact of variables on water consumption:-

1) WATER SYSTEM CHARACTERISTICS.
2) SEASONAL DETERMINATES
3) SOCIAL AND CUSTOMER CHARACTERISTICS
4) CONSERVATION POTENTIAL.

Table 3.1 provides an overview of variables considered within each of these categories. A few variables are considered to represent aspects covering multiple categories.

3.4.1 WATER SYSTEM CHARACTERISTICS

3.4.1.1 PLUMBING LAYOUT

For the purposes of this research on property plumbing is considered as a variable, for households only, in the following three elements;

* The service pipe, from the utility boundary to the rising main stop-tap.
* Internal direct feed plumbing and
* Internal indirect plumbing Service Pipe

CONSIDERATION OF VARIABLES INFLUENCING HOUSEHOLDS AND TRADE CUSTOMERS

TABLE 3.1

VARIABLE	OUTPUT VARIABLE MEASURE	CUSTOMER CLASS
SOCIAL AND CUSTOMER CHARACTERISTICS DETERMINANTS		
Consumer Class Domestic Commercial Industrial	S.I.C	Trade
House Type House Size Street Residential Area House Density Appliance Ownership Pop Density Consumer Class Car Ownship Education Ethnic Minority Income	Acorn	House
Rateable Value	Rateable Value	House
Adults Children At Home/Day Void Property	Occupancy	House
People Using Site	Equivalent Fulltime	Trade/House
Relative Size	Annual Production Annual Turnover Site Area	Trade
Cap Invest	Years On Site	Trade
	Garden Size	House
Water Uses	Washing Process Domestic	Trade

Sheet 1

CONSIDERATION OF VARIABLES INFLUENCING HOUSEHOLDS AND TRADE CUSTOMERS

TABLE 3.1

VARIABLE	OUTPUT VARIABLE MEASURE	CUSTOMER CLASS
SEASONAL **		**SEASONAL**
Seasonal Variation Time Related Variable Time Related Variable	Seasonal Production Shift Working Working Patterns	Trade
Season Climate Holidays Temperature Precipitation	Test Period	House
PHYSICAL **		**PHYSICAL**
Accuracy	Meter Spec	House
Plumbing Style Modification Potential Plumbing Condition House Design Appliance Ownership	Prop Age	House
Plumbing Style Modification Potential Plumbing Condition Poperty Design Plant Type	Years On Site	Trade
Distribution Potential Distribution Potential Distribution Potential Distribution Potential Distribution Potential Distribution Potential	Main Age Main Size Main Material Street Pressure Street Flow Inside House Flow	House
Demand Potential	Nr Supplies Size Supplies	Trade
Natural Restriction Artificial Restriction	Moderated Factor	House

Sheet 2

CONSIDERATION OF VARIABLES INFLUENCING HOUSEHOLDS AND TRADE CUSTOMERS

TABLE 3.1

VARIABLE	OUTPUT VARIABLE MEASURE	CUSTOMER CLASS
CONSERVATION POTENTIAL	********CONSERVATION POTENTIAL	
Price Sensitivity	Know Bill Pay by Meter Assessment of Bill Water Price	Trade/House
Potential Savings Conservation Sensitivity	Last Appeal Conservation Measure Pressure Volume	Trade
OUTPUT VARIABLE	*************************** OUTPUT VARIABLE	
Annual Consumption Annual Water Bill	Water Used & Cost	Trade
Daily Consumption	L/Prop/Day L/Connection/Day L/Person/Day	Hosue
Production Measure	Annual Output	Trade

Sheet 3

A small-bore underground pipe connects properties to the water-main, which normally runs in the road. Ownership of this pipe, known as the service, changes from that of the utility to that of the customer at the property boundary. In most instances this occurs at the rear of the footway. Households and most commercial property are fed through services of, for example, half inch diameter.

Service laying practices have changed over the 150 year history of the UK water industry particularly with respect to pipe material. In practice small-bore service pipe materials are most commonly found as lead, copper or plastic. Since 1988, at South Staffs, new and replacement services have been laid in Medium Density Polyethylene.

In anticipation of long-term potential for increases in customer requirements larger bore pipework has been adopted as a minimum standard. Minimum service sizes now being laid approximate to 3/4" nominal bore (25mm O.D).

Once past the property boundary the service continues, as the customer's responsibility, laid by the builder. The majority of households retain the on-property element of the service pipe laid when the house was originally constructed.

Blocks of houses, typically referred to as "terraced", have commonly been laid with one service feeding multiple properties. Such layouts are termed "shared-supply". This is assumed to be a factor of significant influence upon household consumption, because the supply available from one small-bore pipe has to be shared amongst multiple properties. Influencing the situation further are the facts that:

* multiple simultaneous draw-off is likely to occur.
* that the properties and service pipes are likely to be old and hence in poor condition and
* that pipe runs will by necessity be long to reach the most distant house.

Variation experienced at South Staffs range from single supplies, to newer and/or "higher-class" houses, through to sixteen properties sharing one 1/2" service.

For these reasons I have assumed that properties supplied by a shared service are likely to consume less water due to the physical restriction of the shared service and the local influence of simultaneous draw-off.

Detail of properties per connection is readily obtained by inspection at the property boundary.

It is conjectured that the combined restrictive effects imposed upon customers served by shared services are greater than influences that would be developed through the use of deliberately applied demand-management.

INTERNAL PLUMBING

The service pipe continues into the house and, normally, terminates at the rising main stop-cock, conventionally located in the kitchen. A direct supply feeds to the kitchen sink tap thus providing a direct connection to external water supplies. Measurements of flow, pressure and, when required, water quality taken at this point provide the most accurate correlation to utility standards-of-service within the house.

Beyond this point the plumbing layout will reflect the method practised by the builder or modifications imposed during the properties's life.

Other appliances may be fed directly by cold water at mains pressure. In a direct system, most common in the North of England, baths, instantaneous showers, wash basins and toilets would be included. Hot water systems would be fed via cold water storage tanks (cisterns) in an indirect manner.

Where hot, and most cold water, appliances are fed indirectly, via tanks, the system is termed indirect and this system is traditionally to be found mainly in Southern England.

Recent plumbing practices are changing with, for example, the advent of direct feed heating units such as unvented hot water systems and combination boilers.

It is considered likely that, under similar conditions, indirect plumbing systems would use lower quantities of water. The logic for this statement is based upon the fact that more appliances would be supplied at lower pressure, through cisterns on indirect systems. If correct this would provide further support for the assumption that, without customers being aware, potential consumption is modified, whilst demand expectations continue to be satisfied.

The potential for modifications, subsequent to construction, increases with property age. In this respect modifications are commonly made without regard to original design or current bye-law approval. Determination of actual internal layout is therefore impossible without a full internal inspection.

Experience at South Staffs has shown that customers are unwilling to subject themselves to plumbing inspections which may result in property damage and bye-law enforcement. Generalisations can be made but are considered likely to yield misleading information particularly on older property.

PLUMBING SUMMARY

It has been assumed that properties of similar age and design within any given street would be subject to similar internal plumbing. Original development inspection records held by South Staffs Water confirmed this as correct. A sample of four properties were inspected to assess actual internal plumbing layout. This confirmed the view that subsequent modifications rendered knowledge of original plumbing layout practically worthless as a reliable predictor. This uncertainty was compounded by the degree of difficulty experienced whilst attempting to determine current plumbing layouts. The most notable problem concerned damage to decoration whilst inspecting concealed fittings.

Thus whilst it was dictated that reliable representation off internal plumbing required actual inspection, this was unlikely to meet with customer approval. For these reasons internal plumbing as a variable was excluded. However a surrogate was required to represent variations in plumbing layout and hence the influence on consumption.

The fact of separate or shared service was assumed to be of greater significance. Evidence for this variable is readily available and can be collected by examining stop-taps, external to the property, without necessarily alarming residents. This variable was therefore carried forward for investigation.

Plumbing Layout: Summary of related assumptions

* that a shared supply will significantly reduce consumption per property
* that an increasing ratio of properties per connection will reduce consumption per property so served.
* that the layout of internal plumbing may influence consumption, (however, a surrogate variable for internal layout is necessary).

3.4.1.2 PROPERTY AGE

From the examination of original development plans, undertaken whilst considering plumbing layout, there was a strong correlation between age, property design and internal plumbing. Therefore property age was selected as a surrogate partially representing internal plumbing. The age of a property is readily available from records.

Age is also likely to provide an indicator of plumbing condition, pipe material, the potential for on-property modifications and possibly appliance ownership.

3.4.1.3 YEARS ON SITE

In determining the potential for modifications to plumbing, the period of current occupancy was considered as a variable. Local Estate Agents reported typical tenure for households as 5 to 10 years. The point was very strongly made that many properties were modified, for example, as schemes forming local authority refurbishment workload. These are undertaken without reference to length of tenancy and very often prior to tenants moving in.

Tenanted property is normally modified as necessary by the owner or landlord rather than the resident. For households this factor was therefore rejected as a variable by virtue of its implied non-representation.
Established time on site was retained as a variable for trade customers partially as a possible descriptor of plumbing design but also for its potential as a measure of "viability" and indication of capital invested, including water consuming plant and equipment. How, or even if, this relationship works in practice is not known. It may be that trade customers with a short history on a given site tend to invest in water efficient plant merely as a coincidence occurring whilst tooling-up for a new enterprise.

Years On Site: Summary of related assumptions.

* The number of years on site is considered as an indicator for trade customers.

3.4.1.4 WATER SUPPLY POTENTIAL

As discussed in sections 2.5.5.7 and 3.1 customer demands can be influenced by modifying the potential of water, available for delivery, from the water utilities distribution system. A detailed analysis of this specific aspect is outside the scope of this research. Such influence cannot however be ignored. As a consequence 6 related variables were identified for households and 2 for measured customers.

HOUSEHOLDS

The Director Generals Standards of Service, for domestic customers, relate to flow and pressure. These generally represent the systems ability to deliver water. Actual Potential to deliver water through these pipes can be measured using sophisticated tests to determine head-loss. This provides a measure of output subject to a range of flow velocities. The reasons for variation in carrying capacity are, however, assessable only by physically inspecting water-pipes. Such inspections were considered but were rejected in favour of simpler indicators having the virtue of being more easily transferable, to research extended elsewhere, lower cost and avoidance of disruption to customers. Three alternatives were adopted for examination in the methodology. These were age, material and size of the water main. Together they provide an indicator of condition and potential for delivery from the water system to the customers boundary.

Referring once more to standard-of-Sevice, the customer is concerned with the service received rather than the operational reasons dictating availability. Supply standards are represented by measuring flow and pressure at customer boundaries. Both are directly related to supply potential, particularly peak rather than average. A further measure was included for consideration to indicate service-pipe influence as discussed in 3.4.1. This was the measurement of flow at customers kitchen taps.

METERED CUSTOMERS

Non-household customers tend to have specified requirements more exactly to meet their business needs. This is particularly so for trade customers using water other than for domestic purposes. Further, many metered trade customers carry internal storage vessels to provide back-siphonage protection, for the public water mains, and an element of on-site supply security. Indeed the provision of such storage was a requirement of connection for certain metered trade customers at South Staffs until approximately 1986.

Larger customers often request multiple feeds to one site to meet supply requirements and as an aid to operational flexibility. Two variables were selected to represent potential for demanding water. These were the numbers and size of individual connections to a given site. The fact of storage would also provide a variable indicating the sites direct dependence upon district supplies.

Water Supply Potential: Summary of related assumptions

For Household Customers

* Water main age, size and material provide an indicator of "external" potential for supply.

* Flow and pressure measured at the boundary will provide a direct measure of a perceived factor influencing consumption potential
* Flow measured internally will represent a measure of influence exerted by the service pipe

For Metered Customers

* The number and size of connections to a site will provide a measure of supply potential
* The availability of on-site storage will provide an indicator of independence from the direct supply system.

3.4.2 SEASONAL DETERMINATES.

A number of sources studies, 2.5.7 and 2.7, identified climatic or seasonal factors as determinates of consumption patterns. This was particularly so in North America but was also reported in Southern England resulting from a combination of high temperatures and holiday makers.

For households the factors of season, climate, temperature, precipitation and holiday periods will be included.

Metered customers will be asked specific questions relating production to similar variables representing seasonal working and adopted multiple shift patterns.

3.4.3 SOCIAL AND CUSTOMER CHARACTERISTICS

Sources presented in the literature review, 2.7.2 and 2.7.3, provided anumber of very clear factors shown to influence consumption. In particular a number of studies demonstrated that socioeconomic factors play a significant role. This research represents all classes of customer including trade and household. Socioeconomic factors relate to household customers only.

The first variable for consideration is therefore the representation of various classes of customer particularly to separate trade and household.

Standard Industry Classifications (S.I.C) (H.M.S.O, 1980) were selected to reconcile with water industry standards and direct comparison with nationally generated statistics. This provided not only the required household/trade separation but also the division of trade customers into subgroups for realistic comparison within similar industry.

Additional "output" measures were required to aid trade customer comparisons. These were selected as production, profit and turnover, capital investment and people on site. From section 2.6.4, a factor representing trade customers site area was also included for consideration as an independent variable.

Storage provision was included as a factor potentially limiting consumption due to operating at lower pressures, as discussed for households, in section 3.3.1, Usage of water on trade customers sites was also identified to reflect varying potential for consumption.

Social determinates representing the diversity of household consumers were selected by reference to the case studies, 2.7.2 and 2.7.3. These provided the following variables:-

HOUSEHOLD VARIABLES
HOUSE TYPE
HOUSE SIZE
STREET
RESIDENTIAL AREA
HOUSING DENSITY
POPULATION DENSITY

SOCIAL CLASS
ETHNIC GROUPS
APPLIANCE OWNERSHIP
CAR OWNERSHIP
EDUCATION
INCOME

The surrogate variable used to represent aspects of each of these will be " A Classification of Residential Neighbourhoods" (ACORN). This approach is discussed in detail in the section 6.2.1.

Households not paying by volume attract water charges via Rateable Value systems. Despite their being considered unrepresentative of water consumption, by central Government, property specific rateable values have been included as a variable. This decision was taken because RV continues to form the charging basis for the majority of household customers in the UK.

People use water and the relationship between occupancy/consumption and property class/consumption has been debated particularly in North America, section 2.7.2. In the U.K., average per-capita is the common representation of household consumption. This value is generally determined by reference to property consumption factored by a remotely assumed population density. The relationship between adults, children and consumption, in the UK, requires investigation to determine what, if any, influence is exerted, case study 2 section 2.7.3 .

A further element of occupancy selected by this research relates to the fact of households being un-occupied during the day. This suggests that the potential for water usage is less but perhaps this is compensated by a higher standard of living.

Finally, in this respect the potential for water use external to the property is considered. Arid countries commonly refer to this variable as "irrigation" and it remains as seasonally significant, case studies 2.7.2 and 2.7.3. In the UK hose-pipe bans are commonly imposed to reduce water using potential, section 2.5.4, yet the overall annual component of water use attributable to garden watering is relatively small. The research provides a comparison between households, with varying garden plots, as an insight to its potential influence on consumption.

Social and Customer Characteristics: Summary of Related Assumptions

* The use of S.I.C codes to represent customer classes as a variable

For Metered Customers

* Independant variables selected ; people on site, output, turn-over, profit and site area
* Identification of on-site water use by trade customers.

For Households

* subdivided into ACORN groups to represent socioeconomic determinates.
* Inclusion of Rateable Value as an independent indicator of property value.
* Measures of occupancy including adults, children and "at-home-in-day".
* Garden size as an indicator of potential external usage.

3.4.4 CONSERVATION POTENTIAL

North American research, 2.7.2 and 2.7.3(case studies), demonstrated that water price is the variable most likely to stimulate conservation.

At South Staffs Water, and generally in the UK the "no-discrimination" approach and the conventional direct charging approach has provided little scope for tariff control. To obtain a view of customers sensitivity a different approach was therefore required.

A number of variables were identified which, when pooled, may provide a measure of for example conservation potential either with or without customer knowledge.

For Metered Customers

The first variable relates to the customers knowledge of current usage and cost of water bills. This will be expanded to obtain the customers perception to the bills equity.

An assessment of the customers knowledge of water conservation practices and equipment will be undertaken with particular reference to steps enforced or planned on-site. The sites sensitivity to changing standards-of-service will be assessed. Finally knowledge of previous "appeals" to voluntarily conserve water will be tested to indicate responsiveness.

For Households

Similarly the lack of tariff availability for householders requires an alternative approach to asses variables influencing consumption. A realistic output, or dependant variable, monitoring consumption requires customers to be metered. The sample must be representative of the whole spectrum of households to allow comparison across socio-economic groups.

It is the intention of this research to subject selected consumers to a device capable of directly altering the potential for water demand. It is anticipated that such a device will not necessarily reduce average consumption across all, or any, customer groups but rather it will impact upon peak demands particularly those households consuming above average quantities of water.

3.5 RESEARCH OBJECTIVES.

The original objective of this research was to assess customer reaction to water metering. Particular reference was to have been made to paying for water by volume and thus being given an opportunity to influence the overall cost of water services. In turn this would have provided an independent assessment of customer sensitivity to price.

In practice, in 1985 and 1986, lack of suitable legislation, the difficulty in obtaining a representative sample and the cost of metering several hundred customers precluded this approach. Subsequently the National Metering Trials presented an opportunity for a far larger sample of household customers to be subject to metering, including the countries first experiences of tariff control. The interim results of this trial are discussed in section 2.5.6.2.

A summary of the original aims and objectives is included as appendix A.

The objective of the research developed in two directions. Each making use of different approaches to determine those factors which influenced water consumption. As discussed in section 3.0 the project separated into metered, nominally trade, customers and household, nominally un-metered customers. The required outcome, however, was constant for each:-

* To develop a method capable of determining those factors exerting an influence upon consumption.

Of particular significance the research extended to include the development of a method capable of influencing household consumption.

3.6 FORMULATION OF HYPOTHESES.

This chapter has identified and examined a range of variables potentially influencing water consumption by customers of all classes. For convenience the labels of "household" and "metered" customers have been adopted to match the records of South Staffordshire Water PLC. Households include only customers who use water for domestic purposes. The metered customer base includes; Industrial, commercial and households. Thus water may be used for a complete range of purposes from industrial process to domestic. Such as food preparation, central heating, washing and toilets.

Consideration of the research objectives and the potentially influencing variables provides a suitable opportunity to formulate and declare hypotheses for testing at analysis. The hypotheses will also be used as a framework around which the methodology can be constructed:

HYPOTHESES

HOUSEHOLD ONLY

1. That household water consumption can be modified whilst maintaining customer satisfaction.

2. That household customers are subject to non-policy independent variable which limit consumption.

3. That customers are, in general, insensitive to the price of water.

4. That the influence of "shared supplies" is significant.

5. That older households consume more water.

6. That higher socio-economic classes of property will consume more water.

7. That occupancy relates directly to consumption.

8. That "plot" size relates directly to consumption.

9. That properties unoccupied during the day will use less water.

10. That service, pipe leakage is a significant component of household consumption.

TRADE CUSTOMERS (INDUSTRIAL AND COMMERCIAL)

11. That the provision of bulk storage indicates higher levels of consumption.

12. That patterns of working will influence consumption.

13. That people on-site relate directly to consumption.

14. That larger customers will be more aware of conservation measures.

15. That consumption will be related to SIC grouping.

Part three of the thesis develops methodologies to test the hypotheses with findings reported in part four.

PART THREE

APPLICATION OF RESEARCH

CHAPTER 4

OUTLINE OF METHODOLOGY

4.0 INTRODUCTION TO PART THREE

In part two, a series of problems and some solutions were identified. In general these demonstrated that numerous variables affected water consumption but that nearly all research had been conducted outside of the UK. The two exceptions to this are the National Metering Trials, investigating effects of metering on households, and the work undertaken by Smith (1985), investigating declining industrial water consumption.

Both of these works correlate customer consumption with reference to only limited variables. The National Metering Trials monitored an extensive sample of households and provided the first insight into both UK service pipe leakage and customer reaction to water tariffs. Subsequently The National Consumer Council criticised the methodology adopted for the trial. Further, the fact that customers were paying by volume may have masked those variables, other than price, influencing consumption.

With specific reference to industrial, metered non-household, customers Smith provided a conclusion linking consumption to site area. He also constructed a model demonstrating that a relationship was evident between industrial consumption and the indexes of manufacturing output and unemployment.

Both references concentrated upon sumated outputs for total customer groups, i.e. metered households and the largest industrial consumers. The purpose was to obtain an overview for forecasting and prediction. Neither work had the terms of reference to consider variables potentially determining individual consumption.

External to the UK, substantial works have been undertaken and variables identified . This is particularly true for households in North America. Studies have, however, concentrated upon either the price of water or purely social determinates. Industrial customers have not been analysed to determine individual determinants of consumption. Once again they have been grouped to predict future consumption on historic trends.

In the majority of cases control of demand has been applied as a crisis measure to restrict, temporarily, limited supplies. Such extremes are normally accompanied by substantial "education" using a variety of local and national media sources. The water utilities strive to alter customers behaviour in a deliberate and overt manner.

Trials require measurement to provide the basis for comparison and water meters are most commonly used. Customers involved in such research therefore pay for water, by volume, through the meters used to monitor consumption. In the UK, new household customers or those existing customers perceiving an advantage, and volunteering to be metered, are, generally, the only customers with such a device fitted. The readily available pool of metered households, representing 2.6%, CRI (1992), of UK households, is therefore biased in favour of new supplies and customers living in high rated or low consumption properties.

With this information in mind a survey of consumption could be undertaken to determine influencing variables. What, however of the majority of properties constructed years ago subject to shared and poor condition service pipes. What also of the customers who do not want or have not even considered water metering as an option. This group represents 97.4% of UK households.

The objective of this research, presented in section 3.4, is to determine those factors which may exert an influence upon consumption.

That consumption can be influenced is beyond doubt, witness the evidence documented in sections 2.5 and 2.7. The author also contends that a series of non-policy, independant, variables modify consumption, as discussed in sections 3.0 and 3.2. These generally occur without the customer being aware and are indicative of water usage well in excess of basic needs.

Four broad areas of variable, potentially relating circumstances to consumption, were developed, at length, in section 3.3 these are:-

1. Water System Characteristics
2. Seasonal Determinates.
3. Social and Customer Characteristics.
4. Conservation Potential.

The purpose of this research is to determine whether customer consumption can be modified. Two distinct customer groups have been identified and it is proposed to use a different approach for each. With specific reference to households the research will involve selecting, and if necessary developing, a device capable of influencing on-property consumption. To enable the effects of such a device to be measured other variables will require assessment.

The analysis methodology, developed with reference to the literature review, is presented as Section 4.1 in recognition of its commonality to both sample sets.

Part three continues with a detailed account of the methodology developed to obtain samples. In contrast to the analysis section the two approaches are markedly different and apply to two broadly different customer groups. Consequently, Chapters 5, 6 and 7 relate solely to the household sample and Chapter 8 to the metered sample. Chapters five and six also deal extensively with the development and application of the demand influencing device which is detailed as a major element of this research.

4.1 ANALYSIS METHODOLOGY

Once collected, the data was assembled on spreadsheets using Lotus 1,2,3 (version 2.3). Analysis of test samples outside of final selections indicated a number of alterations to questionnaire design. Together with the psychology of approach these were incorporated to assist in the final collection of data.

It was necessary to construct mathamatical models to determine the influence of listed variables. Evidence of correlation was examined in the manner suggested by Gordon (1968). Intercorrelations between sets of variables at 0.6 or greater were subject to further analysis and, in fact, all such cases were removed. Additional checks were undertaken using the variance inflation factor (VIF) to obtain realistic results with variables exhibiting VIF's close to a value of one. All values exceeding one were examined to assess retention, this followed the methodology developed by Neter et al (1985).

Generation of the mdoels was undertaken using multiple regression and an optimum R-sq technique. The models take the general form of

$Q = f(K_1 + K_2I_1 + K_3I_3 + K_nI_n)$

where Q = OUtput measure

K_1 to K_n = constants

I_1 to I_n = Variables identified as significant

In general the criteria for retention in models, apart from VIF approaching 1 were:-

High 't'-ratios

low p values

high R-sq values

high F values

For multiple regression models, variables were considered significant at the 95% level. Where variables were retained falling outside of this limit specific details are given.

CHAPTER 5

THE DEVELOPMENT OF A METHODOLOGY FOR THE DETERMINATION OF VARIABLES INFLUENCING HOUSEHOLD CONSUMPTION INCLUDING THE APPLICATION OF A COVERT DEMAND MANAGEMENT DEVICE

5.0 INTRODUCTION

As previously discussed, the absence of either tariffs or water meters means that 97.4% of UK households are presented with no continuous stimulus to save water. In crisis customers may be urged to reduce consumption through appeals, for voluntary restraint, hosepipe bans or drought orders. The last occurrence of such an event, at South Staffs Water, was during the drought of 1976. Since this time considerable efforts have been focused on improving and maintaining resources to minimise the risk of recurrence.

Apart from national media coverage of water shortage elsewhere in the UK customers of South Staffs Water are, by and large, not exposed to "save-it" campaigns and use water in an unrestricted manner. Metered household customers of course pay for additional volumes used.

In summary therefore household customers at South Staffs generally do not pay for water by volume, are not subject to tariff controls at all and have not been urged to conserve water for many years.

To meet the objectives of the research a stimulus was required to influence customer consumption and obtain a measure of such an influence. Within the research the approach expanded so that, whilst consumption would be influenced, standards of service would be maintained. In effect this meant that only those levels of service in excess of minimum could be modified.

It must be remembered that this research is essentially practical and deals with people who are customers of South Staffordshire Water. The Companies prime concern is to satisfy its customers requirements. Adopting the approach discussed allowed the research to continue without compremising either ethics or policy.

In seeking an applicable measure to influence household consumption three phases of research methodology were identified. These were:-

1. The identification and development of a suitable influencing device including proving trials.
2. Detailed and extensive trials to determine the effects of applying the influencing device to household customers.
3. Analysis of results.

The methodology developed to pursue each of these stages is presented separately in the order identified.

5.1 THE IDENTIFICATION OF AN INFLUENCING DEVICE

With reference to Section 2.5.2 reviewing demand management, four methods of influencing consumption were examined: Educational and regulatory approaches were considered as crisis management tools. Pricing techniques generally covered those customers, paying by meter, being encouraged to reduce excess consumption through tariffs. The fourth option, operational control, was therefore isolated, by a process of elimination, as the approach to adopt for non-metered households outside of crisis.

Of course, for example, in North America long-term shortages are addressed using physical influencing devices, such as retrofitted toilet dams, in conjunction with other approaches. In the UK hosepipe licences are charged for by some water utilities as a crude form of summer/winter tariff. So there is flexibility and the four approaches defined in section 2.5.2 are available for use at the water industries discretion on a mix and match basis to achieve desired requirements.

The statement that operational control methods provide the only non-crisis approach for unmetered customers was however adopted as the key to identify a method of influencing customer consumption. This is in marked contrast to the objectives of the original research which proposed fitting water meters and employing tariffs, included as Appendix A.

5.2 PARAMATERS AND PRACTICAL CONSTRAINTS

To correspond with the objectives of this research a method capable of determining those factors influencing household water consumption was required. An approach that avoided overtly influencing customer behaviour had been selected, as appropriate, so that a measure of non-policy independent variable could be determined. The logic behind this approach was that once influencing factors were recognised demand management could be targeted to specified customer groups. If however, behaviour was altered, through appeals or direct approaches, underlying determinants may have been masked thus devaluing interrelationships.

Section 2.5.5 identified two methods of controlling demand through the application of physical techniques. These were termed point-of-use and whole-property approaches. The first typically involved gaining customer approval to uprate the conservation potential of water using appliances. This was excluded, from this research, by virtue of having to involve the customer. As a minimum, customer approval to enter property would have been required. Further, it was considered prohibitively expensive to purchase and instal equipment governing all points of usage. A practical adoption of this approach would have meant that specific appliances would have been targeted to optimise influence on consumption. From the review this would certainly have included, for example, toilets.

The selection was therefore made on the basis that equipment would be fitted which enabled entire households to be influenced and without alerting customers to the fact of its installation.

The dependant variable was a measure of per-property water consumption. Thus the provision of a water meter at each selected connection was dictated. To avoid the inherent bias towards household customers already paying by volume the research required water meters to be specially fitted and used as monitoring devices only.

Work reported in the Second Interim Report Of the National Metering Trials (WRc 1992), demonstrated that meters fitted inside properties generally exhibited lower water consumption than those fitted at the boundary. The conclusion drawn is that the difference provides an assessment of service pipe leakage approximating to 32 litres/property/day.

When considering plumbing variables, in section 3.3.1, aspects of service pipe layout relating to shared services were hypothesised as being a potential consumption influencer.

For both of these reasons and to minimise disruption to the customer the decision was taken to fit water meters at the boundary. Hence all aspects of on-property consumption were monitored at a single point for each service pipe connected to the water main. This decision is echoed by Company policy, to fit water meters to new property at the boundary, for precisely the same reasons.

A further consideration was the requirement to determine the variables of flow and pressure, discussed in section 3.3.1. These were identified as indicating delivery potential of water in the companies main supply pipes. In accordance with the logic applied to meter location it was also necessary to monitor flow and pressure at household boundaries.

In practice the Company standardised on the use of "boundary-box's" several years ago. These incorporate not only controlling stop-taps and provision for water meters but can also be modified to determine flow and pressures.

Thus to meet research objectives, and for practical reasons, consumption, flow-rates and pressures would all be obtained at household boundaries.

5.3 THE SELECTION OF AN INFLUENCING DEVICE

When the objectives were first considered in 1986/87 national standards-of-service did not exist. The Company, however, had for many years specified customer standards of 15 litres/minute and 15 metres head, measured at the property boundary. These were taken as desirable minimums for research purposes despite being considerably in excess of Director General requirements, which became effective in 1989.

Two options were examined to determine application as a household consumption influencer. These were:-

1. Pressure control
2. Flow control.

U.K. manufacturers were approached to determine proprietary equipment available and to determine interest for manufacture of prototype equipment developed through this research.

5.3.1 PRESSURE CONTROL

Pressure control equipment proved disappointing with, at that time, no suitable UK equipment available; specified as having a stable outlet range of approximately 15 metres head. Contact was eventually made with a Dutch Company who could however provide such equipment.

When trialed the pressure control equipment performed in a most acceptable manner. The same device could also be purchased with a range of differing outlet pressures and combined with a controlling valve. Thus it would be possible to use the device not only as an alternative to a traditional stop tap, fitted at the boundary, but also to encompass a range of pressure settings, if so desired.

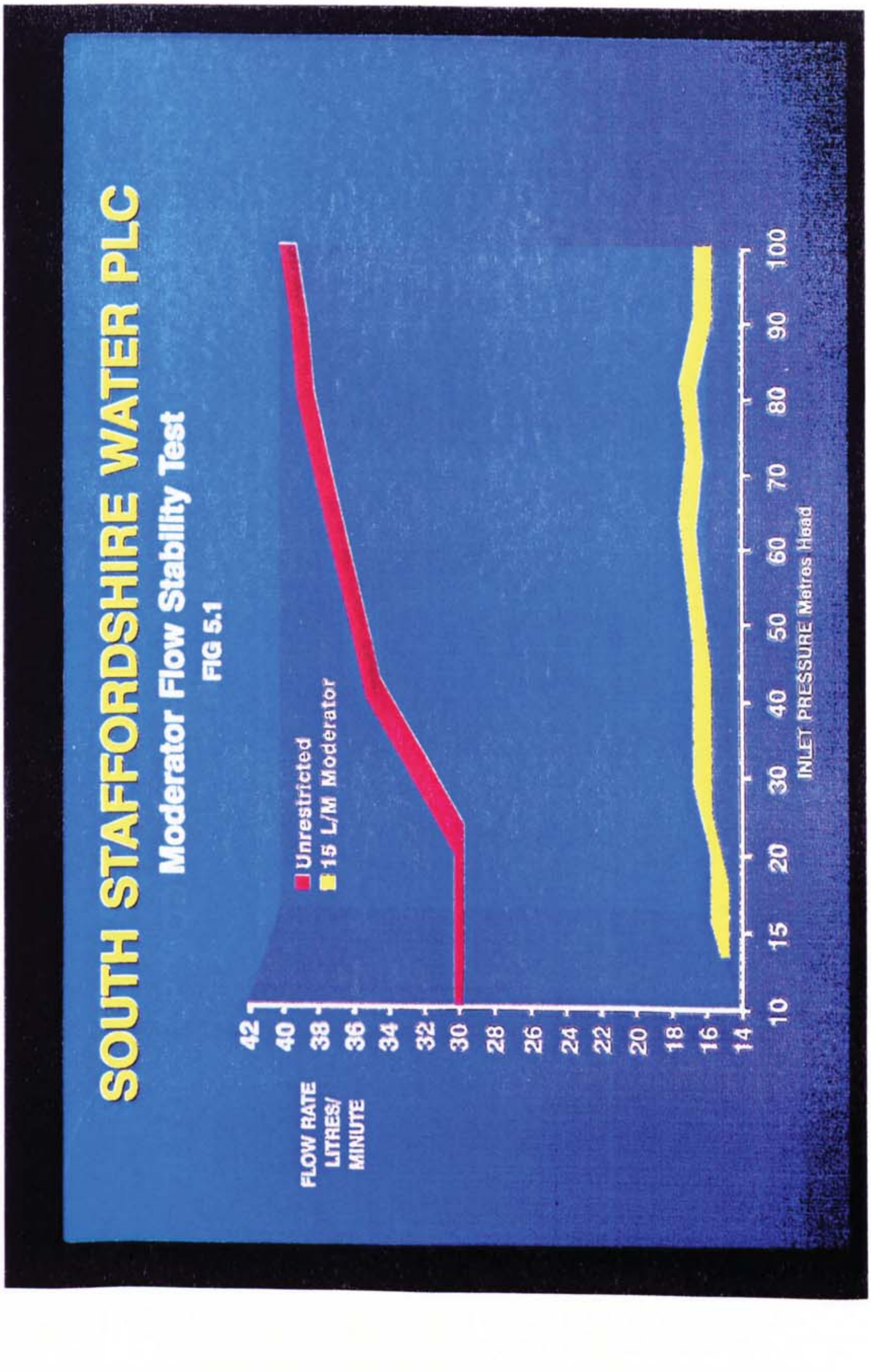
The device did not, however, enable a water meter to be fitted without a separate installation, thus increasing total costs considerably. The trial concluded that the additional purchase and installation cost, approaching £85, would only be considered if a worthwhile alternative could not be identified.

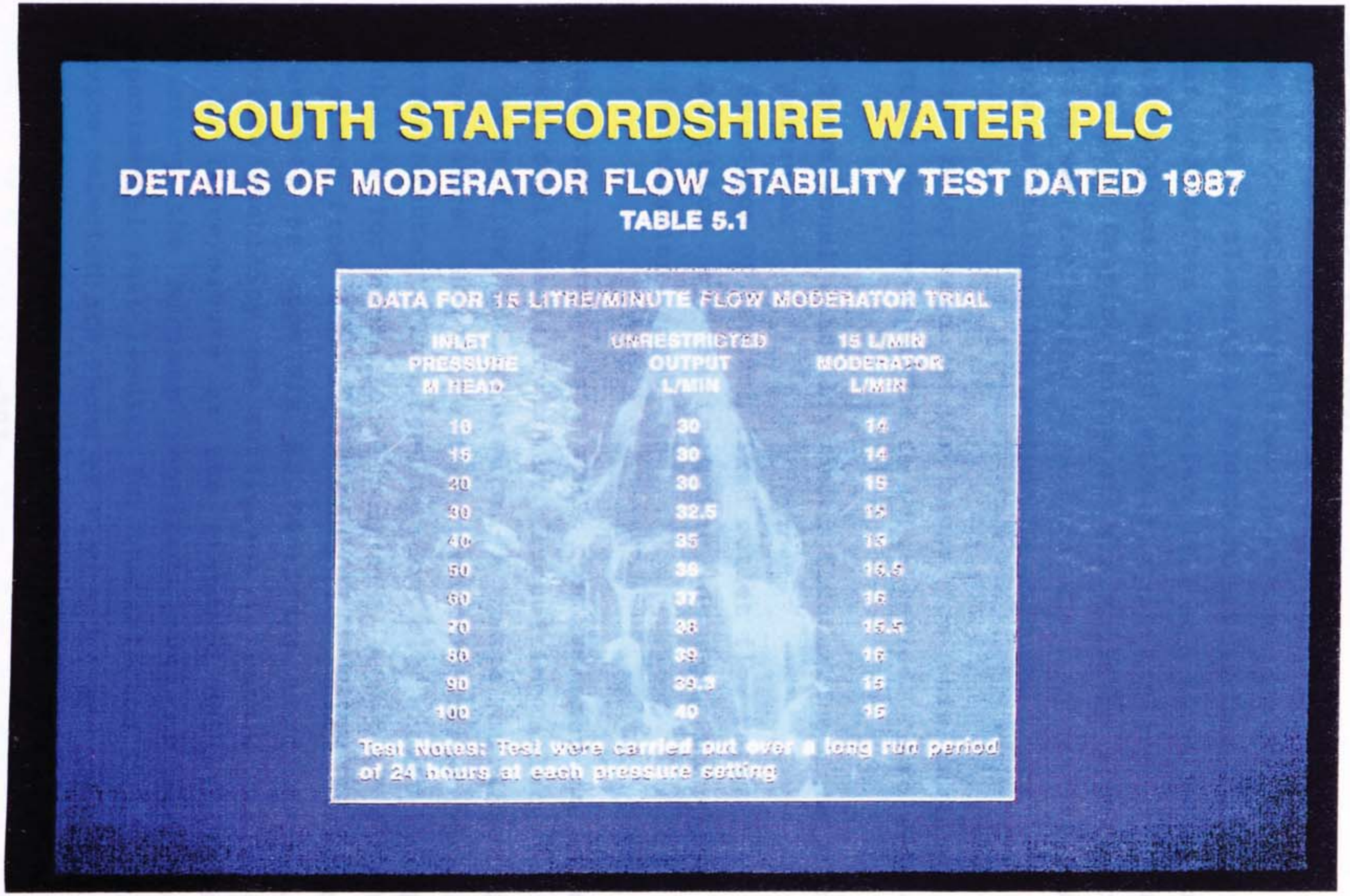
5.3.2 FLOW CONTROL

Three types of flow control device were available. The first consisted of constant outlet devices. At a premium, manufacturers would engineer proprietary equipment to provide the required constant outlet flow of 15 litres/minute. These devices were housed in a separate body and were therefore rejected on similar grounds as the Dutch pressure control device, i.e. cost and separate meter installation required.

The second option provided a low-cost device that could be reengineered to fit in a meter assembly. It operated on a fixed ratio principle in a range to meet customer requirements. Thus devices could be purchased as 2:1, 3:1 or many other combinations. In practice a 2:1 fixed ratio device would halve an inlet flow of, for example, 30 litres/minute to provide the required standard of 15 litres/minute. When these were trialed a reasonable measure of stability was evident.

Application of such a device could therefore match desired standard-of-service in areas of known and constant delivery rates. In a practical situation such stable supply conditions were, however, totally impossible to achieve. It was the device that was required to modify system delivery and not the other way around.


SOUTH STAFFORDSHIRE WATER PLC
Moderator Flow Stability Test
FIG 5.1
Unrestricted
15 L/M Moderator
FLOW RATE LITRES/ MINUTE
42 40 38 36 34 32 30 28 26 24 22 20 18 16 14
10 15 20 30 40 50 60 70 80 90 100
INLET PRESSURE Metres Head



SOUTH STAFFORDSHIRE WATER PLC

DETAILS OF MODERATOR FLOW STABILITY TEST DATED 1987

TABLE 5.1

DATA FOR 15 LITRE/MINUTE FLOW MODERATOR TRIAL

INLET PRESSURE M HEAD	UNRESTRICTED OUTPUT L/MIN	15 L/MIN MODERATOR L/MIN
10	30	14
15	30	14
20	30	15
30	32.5	15
40	35	15
50	36	15.5
60	37	16
70	38	15.5
80	39	16
90	39.3	15
100	40	15

Test Notes: Test were carried out over a long run period of 24 hours at each pressure setting

At extremes, the use of fixed ratio flow control devices could compromise customer supplies by restricting water to a level considerably below acceptable standards. It was concluded that this option was therefore unsuitable and was accordingly rejected.

The third option consisted of an inexpensive device which operated by allowing a predetermined maximum flow to pass. Thus, no matter what system delivery rates were, use of such equipment would equalise instantaneous draw-off potential. Despite being of a simplistic appearance the device was engineered to deform under increasing pressure hence maintaining its maximum throughput.

Before being used as the basis for this research three further requirements had to be satisfied. These were:-

1. Operational stability under fluctuating inlet flow and pressures.
2. Selection of nominal fixed outlet flow rate.
3. Adaption of engineering design to fit meter installation assemblies.

Laboratory based tests were commissioned to determine operational stability under fluctuating inlet conditions of both flow and pressure. A range of fixed outlet flow-rates were tested ranging from 5 to 28 litres/minute. The results for all showed acceptable stability for operational purposes. A set of output data obtained from the experiment, for three settings are presented as appendix B. Resulting confidence in the devices stability was sufficient to enable the selection of 15 litre/minute as the standard outlet value thus matching the minimum required level of service. The experimental test results for the selected 15 litre/minute device selected are shown as Figure 5.1 and table 5.1.

With respect to the third requirement, of adaption for practical use. This was achieved to my specification and design and forms part of a current Patent application. For the purposes of this research publication it is considered sufficient to describe the fact that the device was successfully designed to fit in a meter assembly and modify flow potential to a maximum of 15 litres/minute. For ease of reference the device will now be referred to as The Moderator.

Development of the device to meet practical application on a wide scale formed a substantial and integral element of the research. Mechanical problems were overcome on an experimental basis using prototype devices engineered in differing materials and to differing designs. The majority of the period February 1987 to April 1989 involved the identification of a suitable device and subsequent development to meet practical requirements.

5.4 PROVING TRIALS FOR MODERATOR

The moderator had proven itself in laboratory trials, now it had to be installed on customers property. The requirement for a meter installation to monitor consumption remained. Proving trials were therefore carried out principally on a new housing site where provision for meter installation had been made, at the boundary, as a matter of company policy.

Secondly, to reflect older properties and service pipes one 1950's property was specifically retrofitted with suitable equipment at its boundary.

Selection of the new properties was made on a random basis from a list of some 24 housing estates constructed to include the necessary apparatus. In total this represented 2450 properties. The selected group was not consciously chosen as a sample to represent all households. Indeed as discussed in section 5.2. the limited numbers of properties so fitted prevented a representative sample from being obtained.

The selection of the 1950's property was made on the basis of involving a customer known to the author who would participate in the trials and tolerate intrusion for the purposes of experimental measurement. This led to my Mother's home being selected and equipped with a suitable boundary box.

Considerable disturbance has been imposed at this property whilst monitoring internal flows, pressures and a range of experimental devices to check equipment performance. My thanks are therefore extended to her for the many hours of intrusion to which she has been subject.

Both trial sites, covering 21 properties, demonstrated that customers accepted supplies which had been subject to influence by the Moderator. No adverse comments were received during the proving trial stage and both experimental sites continue to be involved, four years later, thus providing long-term test data. To date none of the 21 properties have registered a single complaint concerning standards-of-service for flow or pressure.

At regular intervals samples from the trial were selected for examination. The check list included:-

1. Wear or breakdown of Moderator.
2. Build up of scale deposits or other debris restricting flow and
3. Conformation of standards-of-supply.

The trials commenced in June 1989 with regular readings to determine household consumption with and without moderators installed. The results indicated overall reductions in consumption of approximately 10% with total compliance of each of the three experimental checks listed above.

1989 PROVING TRIALS ON FLOW MODERATOR DETAILS OF CONSUMPTION AT NEW HOUSING ESTATE

TABLE 5.2

REF	PLOT	MODERATOR 2=Y: 1=N	HOUSE TYPE	DATE	DURATION DAYS	CONSUMPTION m3	CONSUMPTION l/prop/day
1	4	1	D	14/7/89	59	36	607
2	4	2		11/9/89	8	5	590
3	4	2		19/9/89	1000	503	503
4	5	1	D	14/7/89	59	39	661
5	5	2		11/9/89	8	6	726
6	5	2		19/9/89	1000	773	773
7	6	1	B	14/7/89	59	12	197
8	6	2		11/9/89	8	2	252
9	6	2		19/9/89	1000	264	264
10	7	1	D	14/7/89	59	16	278
11	7	2		11/9/89	8	2	253
12	7	2		19/9/89	1000	72	72
13	8	1	D	14/7/89	59	34	584
14	8	2		11/9/89	8	4	469
15	8	2		19/9/89	1000	517	517
16	9	1	D	14/7/89	59	20	343
17	9	2		11/9/89	8	2	297
18	9	2		19/9/89	1000	305	305
19	137	1	S	14/7/89	59	27	451
20	137	2		11/9/89	8	3	373
21	137	2		19/9/89	1000	355	355
22	138	1	S	14/7/89	59	9	153
23	138	2		11/9/89	8	1	136
24	138	2		19/9/89	1000	205	205
25	140	1	S	14/7/89	59	1	16
26	140	2		11/9/89	8	0	22
27	140	2		19/9/89	1000	190	190
28	141	1	B	14/7/89	59	11	188
29	141	1		11/9/89	1008	203	201
30	146	1	B	12/9/89	29	11	379
31	146	2		11/10/89	97	112	1156
32	146	2		16/1/90	881	1095	1243

Sheet 1

1989 PROVING TRIALS ON FLOW MODERATOR DETAILS OF CONSUMPTION AT NEW HOUSING ESTATE

TABLE 5.2

REF	PLOT	MODERATOR 2=Y: 1=N	HOUSE TYPE	DATE	DURATION DAYS	CONSUMPTION m3	CONSUMPTION l/prop/day
33	147	1	D	12/9/89	29	3	93
34	147	2		11/10/89	97	28	289
35	147	2		16/1/90	881	318	361
36	148	1	D	12/9/89	29	2	84
37	148	1		11/10/89	97	17	174
38	148	2		16/1/90	881	126	143
39	170	1	S	12/9/89	29	9	303
40	170	2		11/10/89	97	27	276
41	170	1		16/1/90	881	252	286
42	171	1	S	12/9/89	29	9	320
43	171	1		11/10/89	97	31	316
44	171	2		16/1/90	881	223	254
45	172	1	S	12/9/89	126	0	1
46	172	2		16/1/90	881	11	12
47	191	1	S	12/9/89	29	9	326
48	191	2		11/10/89	97	20	211
49	191	2		16/1/90	881	266	302
50	192	1	S	12/9/89	29	12	408
51	192	2		11/10/89	97	46	471
52	192	2		16/1/90	881	492	559
53	193	1	S	12/9/89	29	0	5
54	193	2		11/10/89	97	30	314
55	193	2		16/1/90	881	249	282
56	195	1	B	14/7/89	59	14	230
57	195	1		11/9/89	1008	190	189

Sheet 2

NEW HOUSING SITE: PROPERTIES CONSTRUCTED FROM MARCH 1989

PROVING TRIALS OF MODERATOR
SUMMARY EFFECTS UPON HOUSEHOLD CONSUMPTION

TABLE 5.3

HOUSE REF	MODERATOR	L/PROP/DAY
13	No	584
39	No	303
47	No	326
16	No	343
43	No	316
37	No	174
42	No	320
19	No	451
4	No	661
22	No	153
10	No	278
1	No	607
HOUSING ESTATE WITHOUT MODERATOR... 376 LITRES/PROP/DAY		
21	Yes	355
40	Yes	276
11	Yes	253
17	Yes	297
5	Yes	726
14	Yes	469
38	Yes	143
23	Yes	136
2	Yes	590
48	Yes	211
HOUSING ESTATE WITH MODERATOR...... 346 LITRES/PROP/DAY		

NOTE: DATA FOR PROPERTIES OCCUPIED DURING TRIAL PERIOD
i.e. excludes voids

Data for the 20 properties on the housing estate are shown as tables 5.2 and 5.3. The summary data clearly identifies average daily consumption savings for similar properties when supplied via a Moderator.

Moderators were fitted to an additional, random, sample of 129 properties in November 1989 to monitor customer reaction. Instructions were issued to Operational and Customer Contact staff to report incidents of complaint, concerning these properties, to myself. No complaints were made.

To verify that all was well in March of 1990 I interviewed residents from 105 of the properties involved. The purpose of the interview was to determine if customers had either noticed any alteration in relevant standards-of-service during the period that Moderators had been fitted. No relevant concerns were expressed. A number of residents declared that "supplies had markedly improved".

Water meters were not fitted to these properties so consumption data was not available. Suggestions that supplies had in fact improved were presumed to be either imagined or as a result of the local communities reduced winter period demands.

The 129 properties involved did not represent a cross-section of households. In particular no households served by shared services were included for reasons detailed in section 5.5.

5.5 EXTENDED TRIALS

To further test customer reaction, to the fact of moderator installation, an extension to the trial was required. On the basis of having no negative reaction, from the limited trials to date, South Staffordshire Water agreed to participate. The decision was taken to install Moderators to all properties, except shared supplies, fitted with boundary-box's. The trial was to be for the six month period July 1990 to January 1991. This included new connections to newly constructed property and replacement or new connections to existing property.

The purpose of the trial was to test customer reaction and to determine what, if any, maintenance requirements the Moderator exhibited. The size of the extended trial rapidly became to large to monitor in detail with, for example, complete streets of older property being fitted with boundary box's as part of the Companies on-going mains refurbishment programme. I took the decision to monitor customer reaction only and selected a few random properties to provide information for case histories.

A passive control was developed using the South Staffordshire Water Incident Management System (SWIMS). This is an electronic register of incidents that occur within the Company's Area. A unique field was created to log incidents, normally emanating as a customer complaint, which were resolved by removing the Moderator from supply. Equipment so removed was returned to myself, with comments, for examination. At the conclusion of the trial some 3000 Moderators had been installed. From this number, 15 incidents were recorded during the six month period.

When examined the, retrieved, Moderators showed no sign of wear or maintenance requirements. Bench testing demonstrated compliance with the original Laboratory trials previously presented as Fig 5.1.

The decision not to fit Moderators to shared services was taken on the grounds that the imposed restrictions of several properties drawing water through a common pipe would be exacerbated. Thus compromising standards-of-service. Two of the reported incidents concerned shared supplies were restrictors should not have been fitted in the first place. A detailed consideration of shared services is presented in section 3.3.1.

The trial concluded with the assessment that no maintenance requirements had been identified and that customers accepted modified supplies without comment for 99.6% of the 3000 property sample.

In view of the lack of detrimental comment from participating customers it was decided to extend the trial. Thus all properties, except shared services, equipped with boundary box's from July 1990 onwards have been included. Some 10000 Moderators are now installed across the Companies area with virtually no comments recorded.

The practical aspects of property selection and inspection plus fitting of the Moderator occupied copious quantities of time. The details of meter reading, checking standards-of-service and interviewing customers added considerably to this burden.

The lack of complaints received by the Company testifies to the customers acceptance of the Moderator.

This research was, however, necessary to determine if such a device actually achieved any savings on a wide-scale. The evidence so far is anecdotal and certainly does not provide a balanced view.

Before moving to develop such a methodology the following case studies are offered for consideration:-

Case Study 1 : 1940's Semi, Large Garden, Large Family, Supply Well in Excess of Minimum

Immediately prior to the Moderator installation flows considerably in excess of 30 litres/minute were recorded at the boundary. District pressures were very high, in the range of 70 to 80 meters head. Flows also in excess of 30 litres/minute were recorded at the kitchen top.

Once fitted, internal flows assumed the Moderated value of 15 litres/minute. Despite this drastic change, no complaints have been forthcoming from the family. Several visits were made in the period immediately after installation to talk to members of the household. Three years later, the same device is still installed.

1950's Detached, Large Garden, Single Occupant, Good Supply

A characteristic of this property was poor internal supplies occasioned by the delivery of customer service pipes in poor condition. Flows and pressure measured at the boundary were 23 litres/minute and 45 meters head respectively. Internal flows were however a lowly 9 litres/minute. The Moderator trial at this site was intended to test the compounded reaction of Moderated flow with very badly blocked or damaged pipes. No alterations in either consumption or flow were evident. Long-term tests have been conducted which verify this point.

1900's Terraced House, Small Garden, Average Supply but Shared Service Pipe

Mistaken installation of a Moderator to a supply serving 6 houses resulted in a very prompt series of phone calls to the Company. Removal of the Moderator resolved the problem. Without the Moderator installed, boundary flow equated to 18 litres/minute whilst spot checks at kitchen stop-taps indicated flows of 8 litres/minute.

Upstream draw off created even worse conditions for the end of line properties who, at times, declared that no flow was available at all. This extreme of on-property determined supply was not witnessed.

CHAPTER 6

APPLICATION OF MODERATOR TO DETERMINE HOUSEHOLD INFLUENCE

6.0 INTRODUCTION

The trials described to date indicate only that the Moderator may conserve water without compromising identified standards-of-service. A number of variables have not been isolated and almost certainly mask relationships between use of the Moderator and household water consumption.

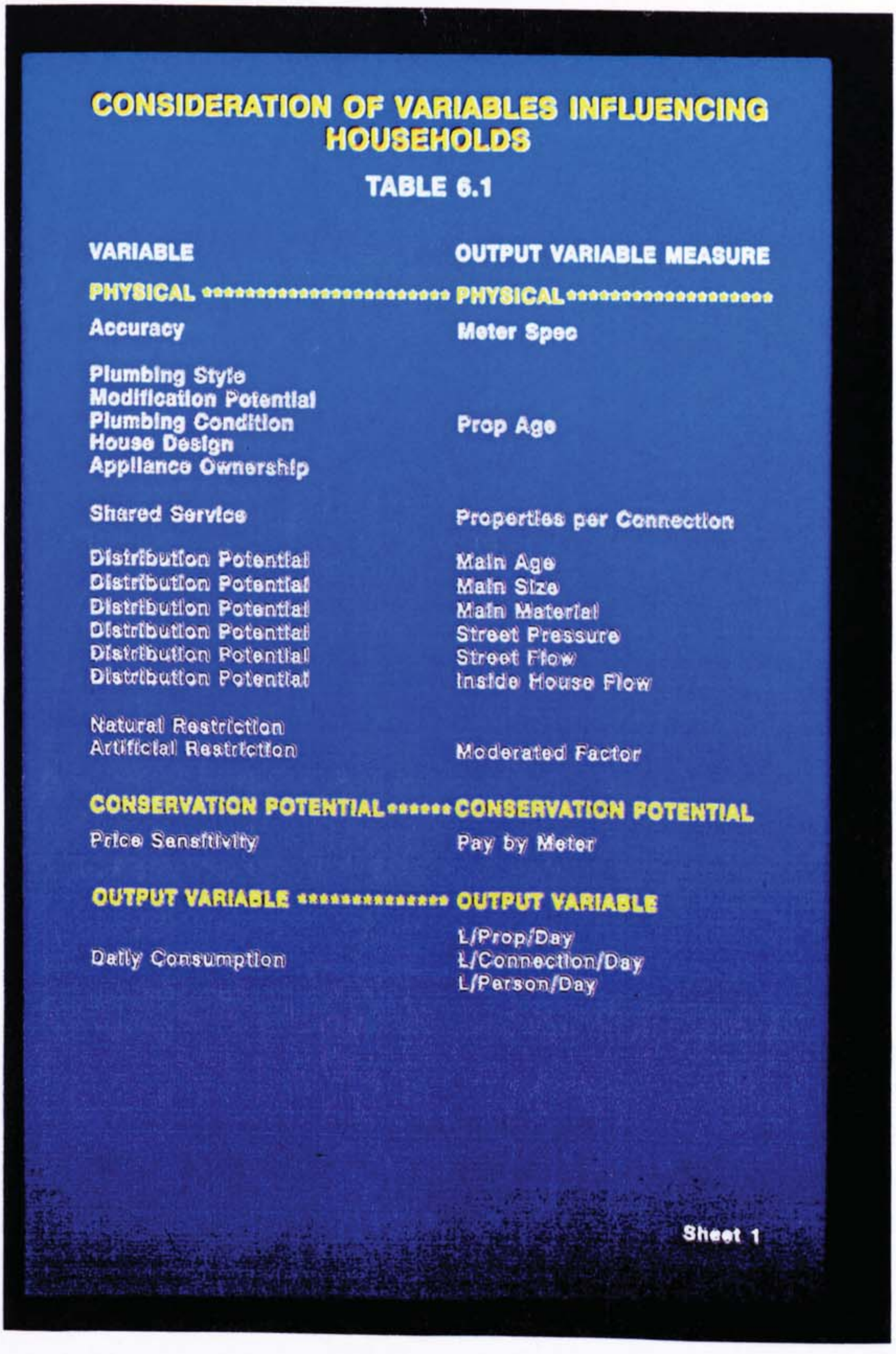
It may be that the Moderator does not, in practice, influence overall consumption but that other underlying variables contribute a combined influence which have been incorrectly attributed to the Moderator.

To isolate and so establish the true influence that the Moderator has, on household supplies, the effects of each variable must be accounted for. The non-policy independant variables, in contrast to the Moderator were described at length in section 3.3 and table 3.1.

This section details the methodology developed to assess the fact, and hence the potential, of the identified variables to influence consumption. Output measures relating variables, for households only, are summarised in table 6.1.

6.1 METHODOLOGY FOR REPRESENTING IDENTIFIED VARIABLES

To enable analysis of consumption data and the associated string of independent variables, a robust methodology was developed. This was vital to ensure repeatability, collection and representation of data. In addition the



CONSIDERATION OF VARIABLES INFLUENCING HOUSEHOLDS

TABLE 6.1

VARIABLE	OUTPUT VARIABLE MEASURE
PHYSICAL **********************	**PHYSICAL** ******************
Accuracy	Meter Spec
Plumbing Style Modification Potential Plumbing Condition House Design Appliance Ownership	Prop Age
Shared Service	Properties per Connection
Distribution Potential	Main Age
Distribution Potential	Main Size
Distribution Potential	Main Material
Distribution Potential	Street Pressure
Distribution Potential	Street Flow
Distribution Potential	Inside House Flow
Natural Restriction Artificial Restriction	Moderated Factor
CONSERVATION POTENTIAL ******	**CONSERVATION POTENTIAL**
Price Sensitivity	Pay by Meter
OUTPUT VARIABLE **************	**OUTPUT VARIABLE**
Daily Consumption	L/Prop/Day L/Connection/Day L/Person/Day

Sheet 1

CONSIDERATION OF VARIABLES INFLUENCING HOUSEHOLDS

TABLE 6.1

VARIABLE	OUTPUT VARIABLE MEASURE
SOCIAL CHARACTERISTICS ******	**SOCIAL CHARACTERISTICS****
House Type House Size Street Residential Area House Density	Meter Spec
Appliance Ownership Pop Density Consumer Class Car Ownership Education Ethnic Minority Income	Acorn
Rateable Value	Rateable Value
Adults Children At Home/Day	Occupancy
Void	Moderated Factor
Water Uses	Garden Size
SEASONAL **********************	**SEASONAL *********************
Season Climate Holidays Temperature Precipitation	Test Period

Sheet 2

sequential logging of information and description of the methodology provides the audit trail considered necessary to satisfy academic requirements.

The four collective categories presented in section 3.3, adjusted in respect of households only, are:-

1. SOCIAL CHARACTERISTICS.
2. SEASONAL DETERMINATES.
3. WATER SYSTEM CHARACTERISTICS AND
4. CONSERVATION POTENTIAL.

6.2 SOCIAL CHARACTERISTICS

6.2.1 ACORN GROUPS

13 variables were identified relating to socioeconomic groupings. These included such considerations as appliance ownership, house type, education and income.

A system of categorising known as ACORN (A Classification Of Residential Neighbourhoods), widely used in the water industry, was selected as being representative of the identified social characteristics. Data for The South Staffordshire Water area and, for comparison, national percentages by household and population are shown as table 6.2 and 6.3 respectively , CACI (1991).

Reference to the spread of households clearly demonstrates that selecting categories representing more than 5%, of company stock, yields six groups totalling 88.1%.. These are, for 1990/91, in order of size:-

REF	DESCRIPTION	%
B	MODERN FAMILY HOUSING, HIGHER INCOME	21.9
C	OLDER HOUSING OF INTERMEDIATE STATUS	17.6
F	COUNCIL ESTATES CATEGORY II	16.8
E	COUNCIL ESTATES CATEGORY I	14.6
J	AFFLUENT SUBURBAN HOUSING	12.1
G	COUNCIL ESTATES CATEGORY III	5.1
		TOTAL....88.1%

The selection of a surrogate variable to represent social profiles was undertaken on the basis of using these 6 groups to represent 88.1% of all housing stock and hence customer characteristics. This methodology avoided contact with customers, during the selection stage, and provided additional assistance by identifying geographical areas in which matching types of households existed. Descriptive details of the six Acorn groupings forming the basis of the trial , together with example illustrations of typical properties are presented as fig 6.1.

The Acorn selection methodology was used as the principle criteria for determining sample properties. The Acorn classification specifically refers to a neighbourhood. Properties were personally inspected to verify matching of Acorn classifications. This proved particularly difficult for the three groups of Council Property.

6.2.2 RATEABLE VALUE.

For some 471000 households, in the Company's area, rateable value remains as the adopted surrogate for charge apportionment. Rates have traditionally been assumed to represent property value. Thus water charges, applied pro-rata to rateable value, increase for properties of increasing worth. Higher value properties were traditionally assumed to consume more water. Therefore charges in-fact were intended to be related to consumption.

The rateable value system is included as a variable to test this theory; i.e. Do properties with a high R.V consume more water.

The system has two disadvantages, however, which reduce its viability as a predictive variable. The first is that properties constructed after September 1989 did not attract a rateable value. This was in anticipation of the abandonment, of the system, in favour of the then Community Charge. Secondly the RV system has generally not been updated for existing properties once constructed. Values may not, therefore, represent realistic comparison between similar houses of differing age.

Rateable Values were extracted from billing records for inclusion in the analysis. In those cases where evidence of relative R.V existed it was applied to post 1989 properties. Alternatively missing values were recorded.

6.2.3 OCCUPANCY

Originally 3 variables relating to occupancy were identified. These were the numbers of adults and children living at each house and whether the property was void i.e. abandoned.

During the survey stage a fourth variable emerged which was considered as potentially significant.

Whilst personnaly knocking on doors, to interview customers, it became apparent that a number of households were not occupied during weekdays. This was recorded and carried to analysis.

A total of four variables relating to occupancy were therefore identified.

In accordance with the adopted approach, customers were generally interviewed at the conclusion of the data collection stage to avoid modification of behaviour.

6.2.4 GARDEN SIZE

The plot size occupied by a property was included as an indicator of external water use. For properties with shared services, including flats, total plot area was equally divided between all units. Estimates of plot size were obtained from personal physical examination of properties. In most cases, properties in each street had similar plots. In general, therefore, an average plot size in square meters, for each street, was caried forward for analysis.

6.3 SEASONAL DETERMINATES

For households, the 5 variables relating to this category were identified as; season, climate, holidays, temperature and precipitation.

Test measurements were to be made at intervals throughout the trial period. Each period was logged to represent seasonal conditions for that period. If at analysis the test period proved significant then dominant seasonal features would be identified. Test readings were originally scheduled to occur from September 1991 to April 1992 thus avoiding bias from high temperatures and the growing season. In practice no seasonal trend during this period was detected Section 10.1. The test was therefore extended to include May, June, July and August 1992, i.e. the summer period.

6.4 WATER SYSTEM DETERMINATES

6.4.1 AGE OF PROPERTY

Sections 3.3.1 and 3.3.4 considered 14 variables describing the utility and household water supply and the plumbing system. Following due consideration a selection of 10 representative variables was made. Property age was taken to represent 5 separate variables relating to internal plumbing. This approach depended upon the related assumption that ACORN groupings would also provide a contributory indicator in association, with age, to describe plumbing.

6.4.2 METER SPECIFICATION

Two variants of one meter design were fitted to sample properties. Whilst each was of similar design and construction one model was supplied to a higher low-flow accuracy. This was assessed as potentially providing a bias with such meters recording higher flows particularly in situations described as "North of England" in section 3.3.1.

Since the model of the meter may have different effects upon consumption it was included as a variable.

6.4.3 PROPERTIES PER CONNECTION

Section 3.3.1 examined in detail the possibility that shared services may influence supply potential. Indeed the section concluded that the naturally occurring restriction imposed by shared services would negate any deliberate influence from use of, for example, the Moderator.

To allow this hypothesis to be tested, details of properties per connection were recorded to provide two items of data for analysis. The first was simply the occurrence of a shared supply. The second used the number of properties per connection to relate mean daily consumption to properties served conventionally with an individual service pipe.

6.5 DISTRIBUTION POTENTIAL

Six variables were identified, in section 3.3.1.4, to represent the potential of the distribution system to provide water to the customer. Of these, mains age, mains size and mains material described the utility water main and its ability to deliver water to the customers boundary. The three variables provided a representation of carrying capacity related to size and condition.

To reduce the number of variables under consideration sample sites were selected from streets were water mains had been replaced or laid as new during the past five years.

This is not considered to reduce the methodologies robust approach because standard-of-service, measured at the property boundary, is considered to represent absolute potential for the property under consideration.

To obtain boundary flow and pressures random sampling was undertaken in all streets, during 5 consecutive days in May 1992.

For properties where flow and pressure were recorded at the boundary customers were approached for permission to measure internal flow at the kitchen tap. In a few instances access was not obtained. In such cases sample internal flows were recorded at adjacent households.

Finally in respect of distribution potential the fact of a Moderator being fitted was recorded for analysis.

6.6 CONSERVATION POTENTIAL

For households, conservation potential would be assessed as a consideration of the analysis, i.e. comparison of households exhibiting common variables but dissimilar consumption. However two alternative indicators were obtained and held for subjective assessment during analysis.

When each of the 516 households were personally visited so that interviews could be conducted to determine occupancy, questions were asked concerning the acceptance of supply. The reply was recorded as either satisfaction or concern. Further probing was undertaken to establish if supplies prior to the trial period were satisfactory and to establish concerns. Particularly for the period when supplied via the moderator.

Due to the random nature of the selection process, within the trial specifications, a few of the 516 properties included in the sample had previously opted to pay via the meter. This information was recorded to determine if such customers exhibited an identifiable trend to conserve water.

6.7 SERVICE PIPE LEAKAGE

In recent months the question of leakage on-property has become an issue of major national debate. UK water utilities complete an annual submission to the Director General (OFWAT) detailing performance for the preceding year. This report, known as the July Return, provides the principle basis for inter-company comparison. OFWAT have developed a measure of efficiency termed Water Delivered. In essence this describes total volumes of water which are consumed by customers. The inverse of Water Delivered includes water lost as leakage and used for operational purposes.

The ratio of Water Delivered to Water Not Delivered presents a measure of efficiency. It is intended that many other performance indicators will be related to Water Delivered thus deriving a system of unit cost comparators.

The fact of leakage occurring on customer property has long been recognised. An estimated 50% of the Leakage Control resources, at South Staffs, are spent in identifying water losses on-property. Responsibility rests, of course, with the customer for maintenance of plumbing beyond the boundary.

Without metering the existence of a leak very often goes unnoticed by customers. Leaks may occur at any point from the boundary to the most distant point of use. Those leaks occurring underground however remain as the most unlikely to be identified. These are referred to as service pipe leakage.

The importance, with respect to Water Delivered, is that water lost in such a manner is regarded as having been delivered to customers. Thus if quantities can be assessed, and therefore accounted for, the sum of Water Not Delivered reduces.

The first national assessment of service pipe leakage was derived from the National Metering Trials. With results indicating typical losses of 32 litres/property/day.

At South Staffordshire Water information in this respect had not been quantified.

Substantial analysis of household consumption has however been undertaken over many years but ignoring potential supply pipe leakage. In practice this is due to the lack of household meters at boundary. Estimates of consumption have therefore been made using either questionnaire approaches, to determine components of water use, or analysis of large diameter meters supplying residential districts. The later method is pursued by excluding measured night flows, on a 24 hour basis, and adding back in a 2 litre/property/hour figure identified in STC Report 26 (1980). Thus a figure net of system leakage is obtained.

The two approaches correlate very closely with household consumption equating to 155.9 litres/person/day for the questionnaire method and 151 litres/person/day for the district meter method.

The district meter approach uses ACORN areas to obtain a representative sample applicable company wide.

The methodology developed in this research will, in contrast, yield total on-property consumption including supply pipe leakage. It is anticipated that reference to abnormal consumptions will indicate the size and frequency of service pipe leakage. Comparison of the two sets of data will be undertaken to provide an estimate of any discrepancies which are likely to be accounted for by on-property leakage. Final confirmation of leakage will be established by visiting suspect households. The normal procedure for notifying customers of probable leaks at their premises will be maintained. Findings relating to magnitude and duration of on-property leakage will be reported in chapter 10.

CHAPTER 7

THE HOUSEHOLD SAMPLE.

7.0 INTRODUCTION

Variables expected to contribute a measure of influence, upon household water consumption, were identified in Chapter 3. The same Chapter focused research design and generated hypotheses for verification. To pursue the objectives it was necessary to obtain a sample of household population. Methodologies to represent identified variables were then developed in Chapters 5 and 6.

This chapter relates how the two, potentially, opposed requirements of representativeness and practicality were satisfied by applying identified methodologies to obtain the sample and undertake subsequent research.

7.1 SELECTION OF HOUSEHOLD SAMPLE

The selection criteria yielded two items which, in practice, proved fundamental in obtaining the sample. The first was the use of ACORN profiles to represent socio-economic groupings. The second was the provision of equipment suitable for housing water meters, Flow Moderator and measuring boundary flows and pressures.

A regional preference was exercised to minimise the area monitored by Operational Staff. Thus the Company's central region was used as the geographic limit in which to search for sample households. This greatly assisted in ensuring related incidents were reported to myself and thus dealt with consistently. A combination of the two criteria was therefore applied to the Companies Central Area, consisting of some 500000 customers.

Within the supply limits of this area, all households, known to be fitted with boundary boxes, were pooled for potential selection. Four methods were employed to generate this information:-

1. All household properties constructed after September 1989.
2. All existing households to which boundary boxes had been fitted and for which job-sheets, recording the fact, were available
3. All households/streets which had been subject to complete mains replacement including communication pipes and boundary boxes.
4. A physical search to determine households suitably equipped but for which records were not available.

An estimated 10000 suitable boundary boxes had been fitted, in the area under consideration, prior to this element of the research commencing in January 1990. The majority of these had been installed complete with new, larger bore, communication pipes providing the connection from mains to property boundary. Additionally most of the installations had taken place concurrently with new or replacement mains pipe being laid in the street. Thus some 90% of the 10000 possible installations were served by a local infrastructure less than four years old.

From the discussions in Chapters 3 and 6, a variable identified as influencing potential supply availability was the carrying capacity of local infrastructure. Reference to table 3.1 shows that associated variables included mains age, size and material.

Consideration of households not only fitted with a boundary box but also supplied via recently installed infrastructure, reduced suitable properties to an estimated 9000. This was considered appropriate, with respect to maintaining a practical approach, consistent with a representative selection.

ACORN categories covering the six groups, together representing 88.1% of household population, were then applied to the identified pool of household property. Selections were made on a random basis with the objective of obtaining a minimum of 40 connections for each ACORN category.

Provisionally selected sites were then personally checked to ensure that no trade or commercial properties had been included in the sample. Between January 1990 and August 1990 I visited each to ensure that the boundary box installation was in correct working order.

The final sample comprised 263 connections supplying 516 properties as detailed:-

ACORN GROUP	NUMBER PROPERTIES	NUMBER CONNECTIONS
B	56	56
C	67	46
E	51	38
F	160	43
G	142	40
J	40	40
TOTAL.......	516..........	263

7.2 INSTALLATION OF TEST EQUIPMENT

At each household, included in the research, water meters were fitted in the boundary box. On the most recent properties meters were already fitted and in use for charging purposes. This was particularly true of ACORN group B comprising numerous houses on modern family housing estates with no provision for Rateable Value.

On properties supplied via separate service pipes, Flow Moderators were fitted to alternate properties. Thus a control sample of 'open' or 'unmodified' households was retained.

The numbers of property served by each connection was determined whilst visiting to read meters. In accordance with Company policy Moderators were originally not to be fitted to properties served via a shared supply.

However, in error, prior to the trial commencing, a number of Moderators had been fitted to an entire street of shared-supply properties. Reports from customers indicated a general improvement in supplies. For this reason, a limited number (10) of Moderators were fitted to shared supply properties at trial commencement to determine effects. 5 were fitted and left in for the complete trial, as a control. However, one property within this sample became void thus reducing the coverage of data at analysis.

Meter serial numbers, time, date and meter reading were recorded when the test commenced. Flows and pressures at boundary were obtained over several intervals but recorded for analysis during May 1991.

7.3 CUSTOMER CONTACT

A consideration of the research was to monitor and modify consumption without directly influencing customer behaviour. Thus when selecting suitable equipment for housing the meter, etc., the boundary box also supplied a remotely accessible point avoiding trespass onto customer property. This approach maintained impartiality and minimised disturbance to the customer.

Throughout the trial period customer comments were collected whilst reading meters, visiting sites or through the Companies telephone handling bureau.

At the conclusion of the meter reading stage. June, July and August 1992, each of the 516 households were personally visited to determine occupancy and to relate customer experiences relevant to the research.

7.4 PROGRAMME

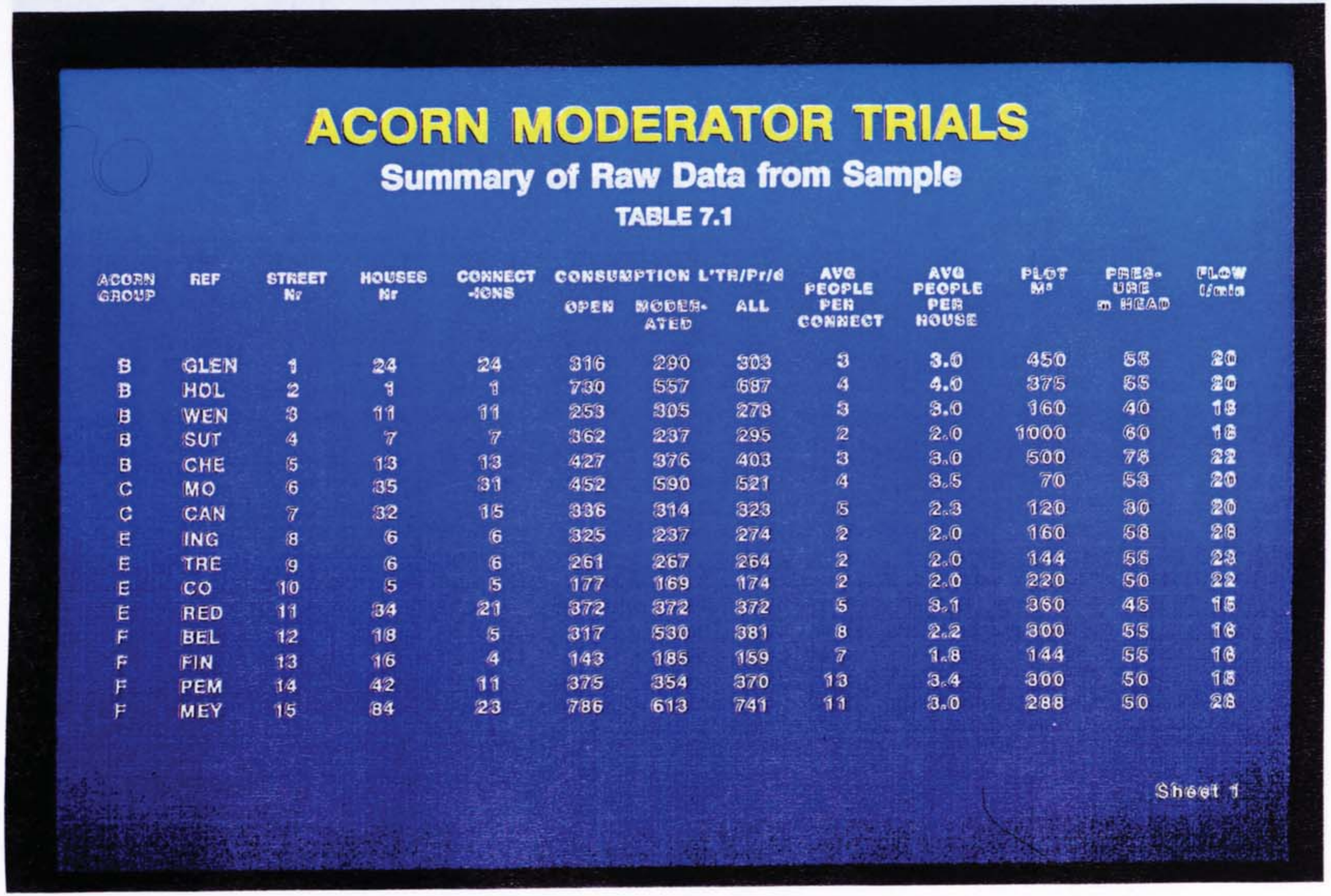
Following completion of the equipment installation phase, consumption monitoring commenced in September 1991. A visit to each property,to read meters, required 5 full days to complete.

Meters were read in October, November and December 1991. January, April, May and June 1992. At this point research was intended to cease for the purposes of data assimilation and analysis. In practice, due to apparent lack of influence exerted upon data by changing season, the research was extended into the summer peripd. Moderators were removed, for examination, and new equipment was installed to those properties previously supplied with unmodified supplies. To continue to provide a measure of control a selection of households were not tampered with at this stage. Additional readings were obtained in July and August of 1992.

Customer surveys were undertaken during the whole of June, July and August. Three properties were visited a total of 9 times, each, before contact with the occupier was made.

7.5 OVERVIEW OF COMPLETE SAMPLE

Table 7.1 provides a summary of raw data presented for each of the 23 separate streets taking part in the trials.



ACORN MODERATOR TRIALS

Summary of Raw Data from Sample

TABLE 7.1

ACORN GROUP	REF	STREET Nr	HOUSES Nr	CONNECT -IONS	CONSUMPTION L'TR/Pr/d OPEN	CONSUMPTION L'TR/Pr/d MODER-ATED	CONSUMPTION L'TR/Pr/d ALL	AVG PEOPLE PER CONNECT	AVG PEOPLE PER HOUSE	PLOT M²	PRES-URE m HEAD	FLOW l/min
B	GLEN	1	24	24	316	290	303	3	3.0	450	55	20
B	HOL	2	1	1	730	557	687	4	4.0	375	55	20
B	WEN	3	11	11	253	305	278	3	3.0	160	40	18
B	SUT	4	7	7	362	237	295	2	2.0	1000	60	18
B	CHE	5	13	13	427	376	403	3	3.0	500	75	22
C	MO	6	35	31	452	590	521	4	3.5	70	53	20
C	CAN	7	32	15	336	314	323	5	2.3	120	30	20
E	ING	8	6	6	325	237	274	2	2.0	160	58	28
E	TRE	9	6	6	261	267	264	2	2.0	144	55	23
E	CO	10	5	5	177	169	174	2	2.0	220	50	22
E	RED	11	34	21	372	372	372	5	3.1	360	45	15
F	BEL	12	18	5	317	530	381	8	2.2	300	55	16
F	FIN	13	16	4	143	185	159	7	1.8	144	55	16
F	PEM	14	42	11	375	354	370	13	3.4	300	50	15
F	MEY	15	84	23	786	613	741	11	3.0	288	50	28

Sheet 1

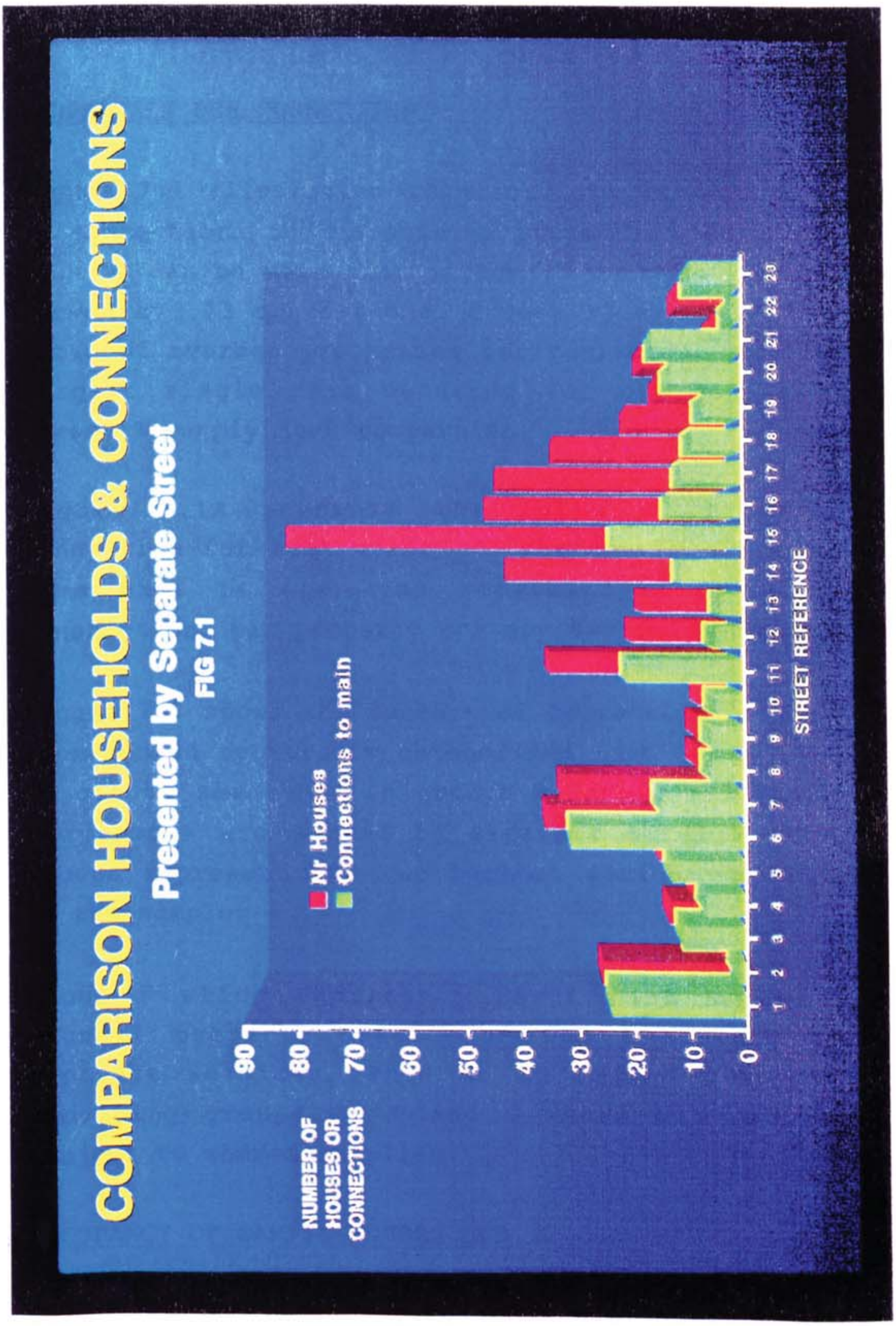
ACORN MODERATOR TRIALS

Summary of Raw Data from Sample

TABLE 7.1

ACORN GROUP	REF	STREET Nr	HOUSES Nr	CONNECT -IONS	CONSUMPTION L'TR/Pr/d OPEN	MODER- ATED	ALL	AVG PEOPLE PER CONNECT	AVG PEOPLE PER HOUSE	PLOT M²	PRES- URE m HEAD	FLOW l/min
G	REM	16	46	13	606	439	564	11	3.1	250	44	20
G	COR	17	44	11	266	287	271	11	2.8	360	48	23
G	MAC	18	33	9	336	359	342	12	3.3	240	40	16
G	BED	19	19	7	354	412	368	8	2.9	200	55	16
J	SUT	20	13	13	530	548	540	3	3.0	1200	60	18
J	SAN	21	16	16	811	502	666	3	3.0	1500	68	28
J	NEW	22	2	2	385	386	385	3	3.0	1500	68	25
J	MEL	23	9	9	570	505	534	3	3.0	1000	46	28
			TOTALS		AVERAGE VALUE			AVERAGE VALUE		AVERAGE VALUE		
			516	263	413	384	401	6	3	471	53	21

Sheet 2


COMPARISON HOUSEHOLDS & CONNECTIONS
Presented by Separate Street
FIG 7.1
Nr Houses
Connections to main
NUMBER OF HOUSES OR CONNECTIONS
0
10
20
30
40
50
60
70
80
90
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
STREET REFERENCE

Please note that this summary includes all values including extremes. Detailed analysis is presented in Part 4 but the following provides observations based upon raw data for the complete sample.

7.6 PROPERTIES PER CONNECTION

Figure 7.1 illustrates relationships between the numbers of connections and associated properties for each street. Thus it can be seen that street 15 contains 84 properties served by 23 connections. Street 13 exhibits the highest ratio of average properties per connection at 4 to 1. The largest single case occurred for one service pipe in street 7 supplying 8 properties.

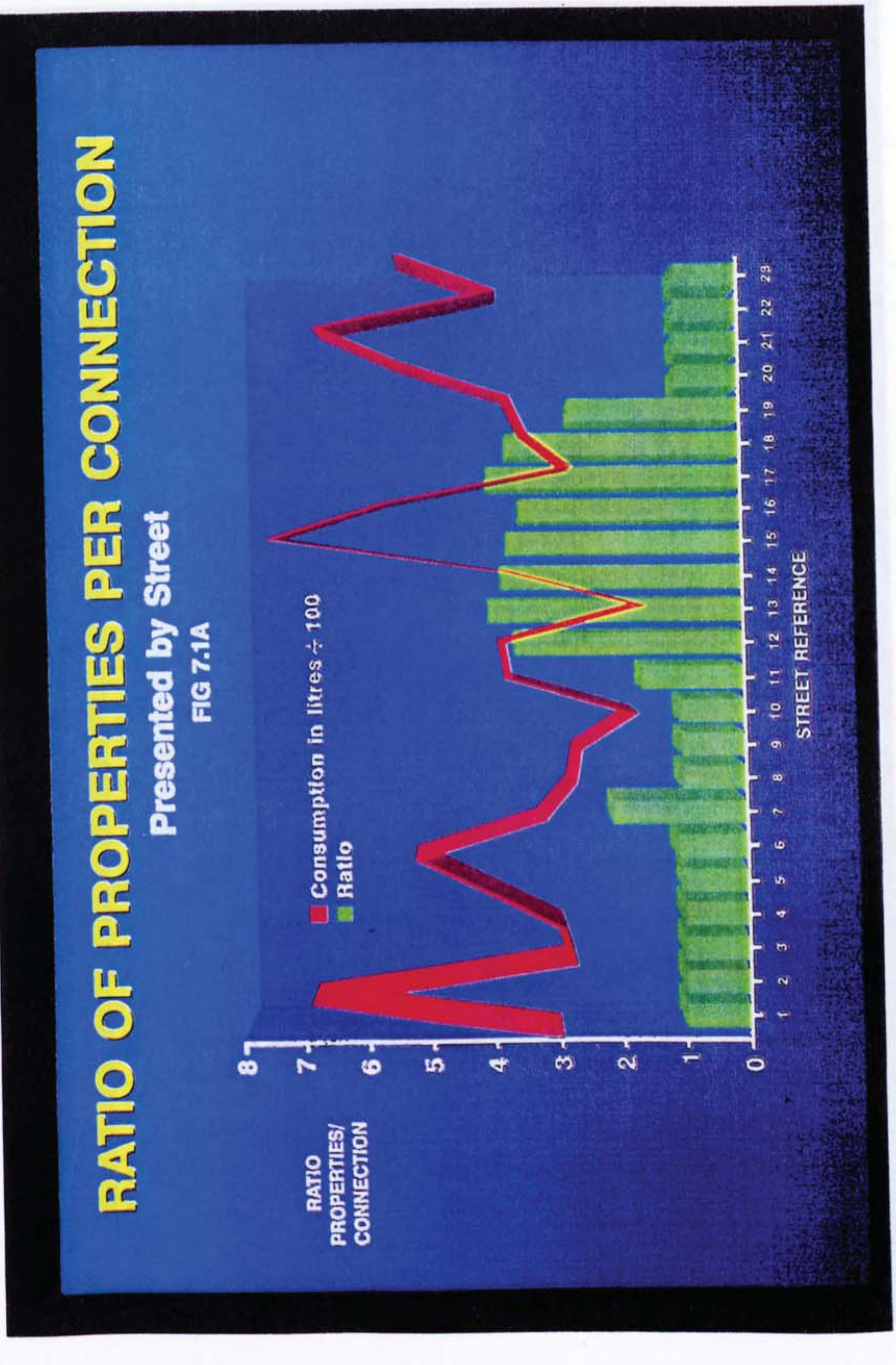
Figure 7.1A presents the ratio of properties per connection for each street in the sample. Included on the same axis is the line representing overall average consumption, per property per day divided by one hundred.

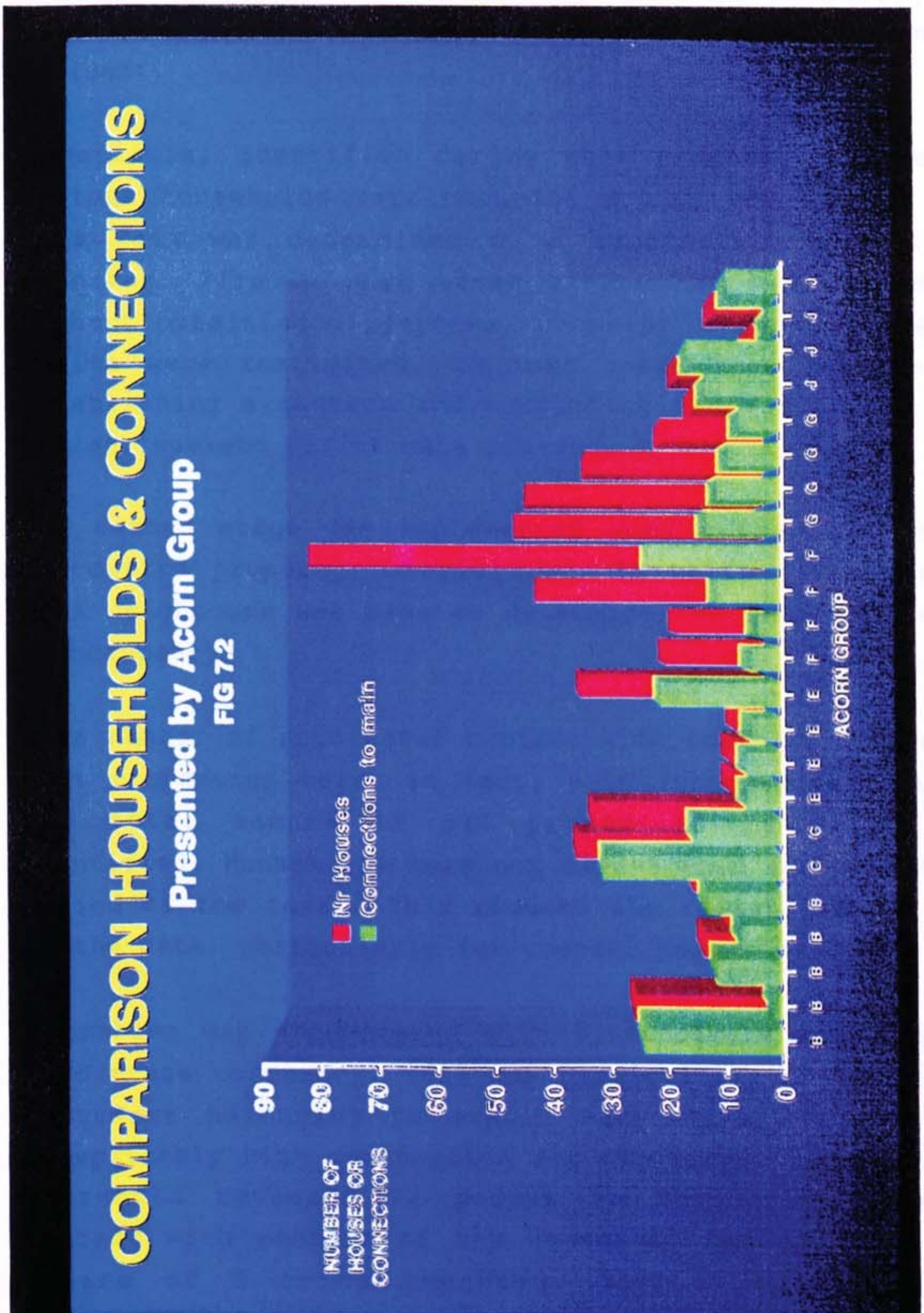
Figure 7.2 shows the numbers of connections and properties represented by streets categorised into ACORN coding. Thus it can be seen that in groups B, and J all properties in the sample are served by separate service pipes. These groups represent the two highest socio- economic classes in the sample.

Group E which represents newer, and higher standard council property, has 3 of its 4 streets served by separate services. This is in marked contrast to the remaining groups C, F and G where all properties are subject to shared supplies.

7.7 OCCUPANCY OF SAMPLE HOUSEHOLDS

Data was collected from all 516 households through personal doorstep surveys. No appointments were made and


RATIO OF PROPERTIES PER CONNECTION
Presented by Street
FIG 7.1A
Consumption in litres ÷ 100
Ratio
RATIO PROPERTIES/ CONNECTION
0
1
2
3
4
5
6
7
8
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
STREET REFERENCE


COMPARISON HOUSEHOLDS & CONNECTIONS
Presented by Acorn Group
FIG 7.2
Nr Houses
Connections to main
NUMBER OF HOUSES OR CONNECTIONS
0
10
20
30
40
50
60
70
80
90
ACORN GROUP

the number of visits per property was recorded. Visits were initially undertaken between 9 AM and 4 PM Monday to Friday. Questions were asked, of householders, to determine the numbers of children and adults normally resident.

A variable, identified during this process, concerned whether households were occupied during the day or not. This fact was determined by a combination of two approaches. Firstly when three visits had been attempted without obtaining a response, from the household, evening visits were instigated. In most cases this resulted in establishing a contact and completing the survey. If this failed, weekend visits were pursued.

The second stage was implemented when a suspicion of an unoccupied property materialised. In these cases contact with neighbours was made to determine the fact and levels of occupancy.

In a number of such cases contact with neighbours revealed that properties were, in fact, void (unoccupied). Out of the total sample of 516 properties 28 voids were identified. Households were not always void for the entire period of the test. This reduced the reliability of some of the data, particularly for council property.

A problem was encountered with householders not prepared to discuss occupancy. This was particularly true of those customers belonging to ethnic minorities. In one case inexplicably high consumption for one large, but terraced, household revealed 12 people in residence. Previous contact with members of the household had resulted in a figure of 5 being reported. Such occurrences were exceptional but directly led to an amendment in survey methodology.

To aid corroboration of occupancy levels, customers were subsequently not only questioned regarding their own property but also that of immediate neighbours.

Information was processed to provide an assessment, for each street, of average occupancy levels per property and people per connection. As with other information presented in this Chapter the data is as collected and therefore includes extreme values, pending analysis.

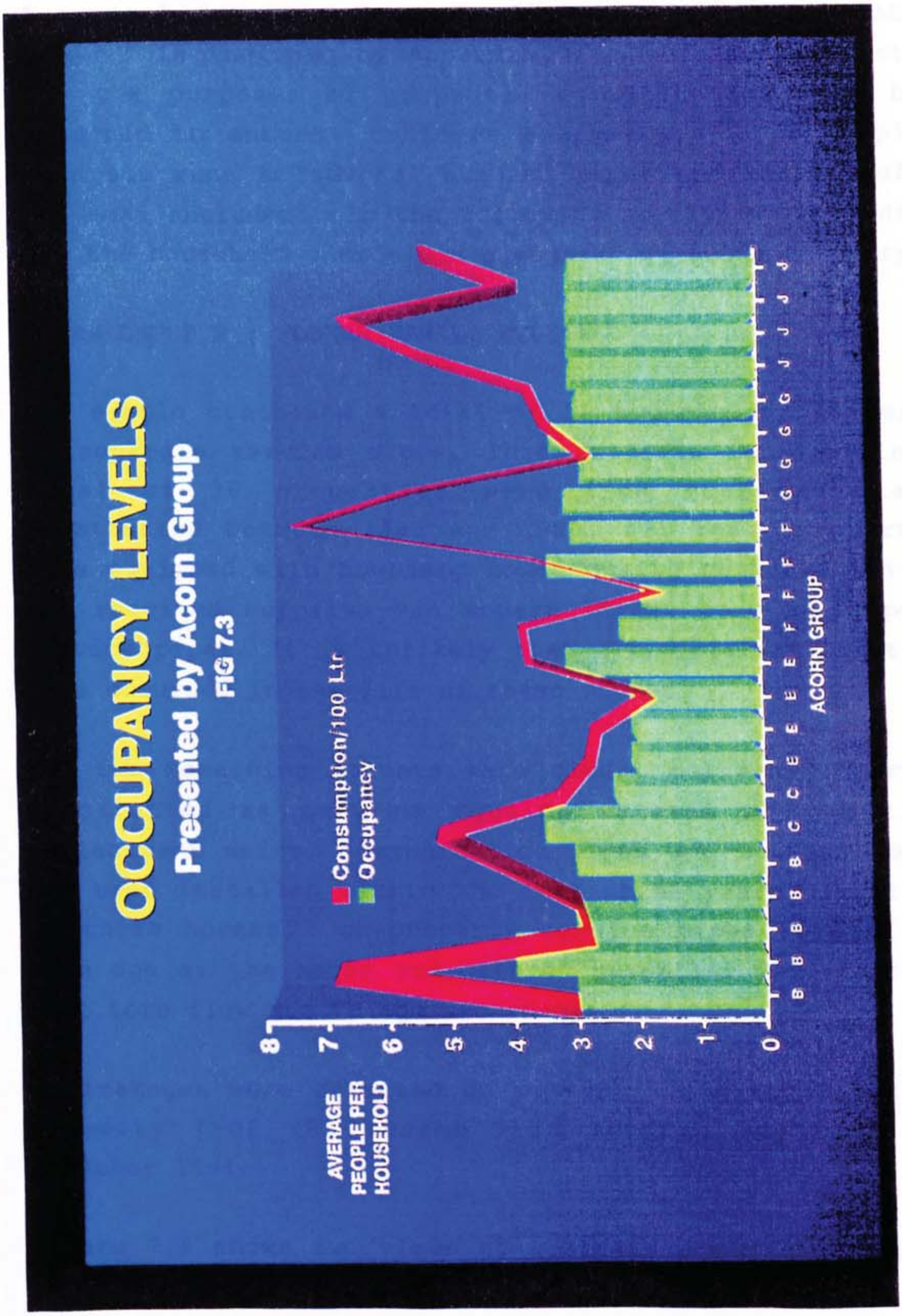
Figure 7.3 shows average occupancy, per property, for each of the 23 streets represented by ACORN category. The line overlaid on the graph reflects consumption trends per property. An approximate relationship appears to be exhibited between occupancy and water consumption.

7.8 OVERVIEW OF EFFECTS OF MODERATOR

Table 7.1 includes information on averages, by street, of household consumption without Moderators fitted (OPEN), with Moderators fitted (MOD) and an overall average. From this information it can be seen that, for the complete sample, unweighted average consumption decreased by 7% from 413 to 384 litres per property.

Reference to figure 7.4 demonstrates that highest consumptions occurred within groups B, F and J. Whereas lowest consumptions were recorded within groups E and F.

The largest conservation effects, from the introduction of the Moderator, occurred to streets within groups J (309 l/p/day), B and F (173 l/p/day) and G (167l/p/day) Conversely the raw data also indicates that introduction of the Moderator corresponded with consumption increases to streets in groups F (213 l/p/day) and C (138 l/p/day). A detailed review of the reasons describing such inconsistencies is undertaken in the analysis section for households, Chapter 10.


OCCUPANCY LEVELS
Presented by Acorn Group
FIG 7.3
Consumption/100 Ltr
Occupancy
AVERAGE PEOPLE PER HOUSEHOLD
0
1
2
3
4
5
6
7
8
B B B B B B C C C E E E E E E E F F F F F G G G G G G J J J J J
ACORN GROUP

7.9 DETAILED DESCRIPTION OF HOUSEHOLD SAMPLE

A typical data set from the household survey for ACORN group J is included as Appendix G. A referencing system, for the purposes of property identification, has been selected to ensure customer anonymity. The complete data set runs to several hundred pages and has therefore not been included. In the following section summary data, for the household sample, is presented by ACORN category.

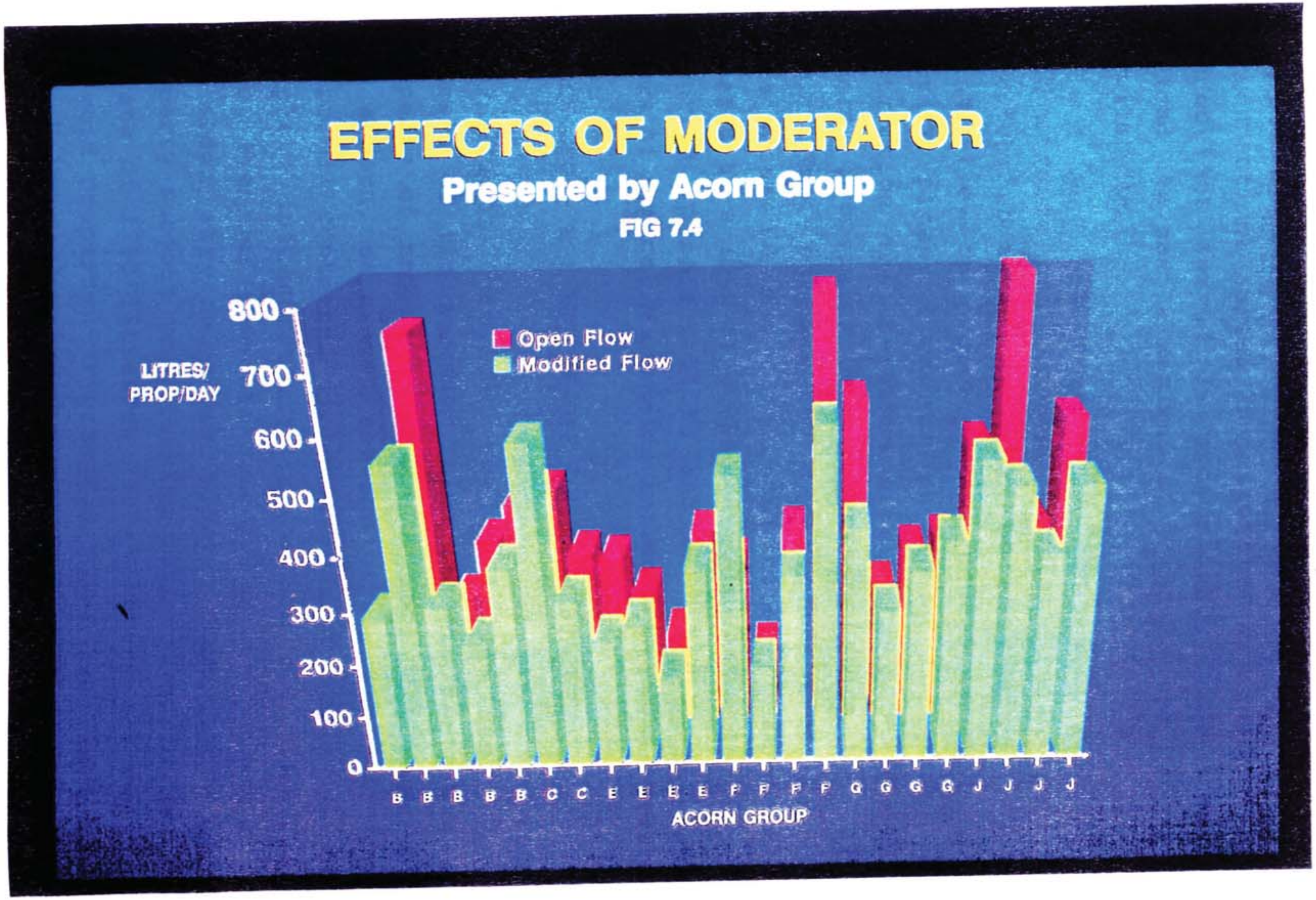
7.9.1 ACORN GROUP B : MODERN FAMILY HOUSING.

The sample contained a total of 56 households all served by separate service pipes. Three streets representing a total of 36 properties were from housing estates constructed between 1986 and 1991. All these properties were equipped with boundary boxes during construction and all received supplies via modern larger bore on-property service pipes. It is unlikely that artificial restrictions have occurred in the life of these houses.

The two remaining streets were older, postwar properties constructed as part of housing estates of the time. Replacement mains, communication pipes and boundary boxes had been installed within the last three years. In all 20 of these houses, on-property service pipes were of the same age as the house and offered potential resistance to full bore flow due to age and condition.

No leakages were detected on property in group B but one property (ref 28) became void between September and December 1991.

Figure 7.5 shows two views of typical households included in ACORN category B.


EFFECTS OF MODERATOR
Presented by Acorn Group
FIG 7.4
Open Flow
Modified Flow
LITRES/
PROP/DAY
800
700
600
500
400
300
200
100
0
B B B B B C C E E E E F F F F G G G G J J J J
ACORN GROUP

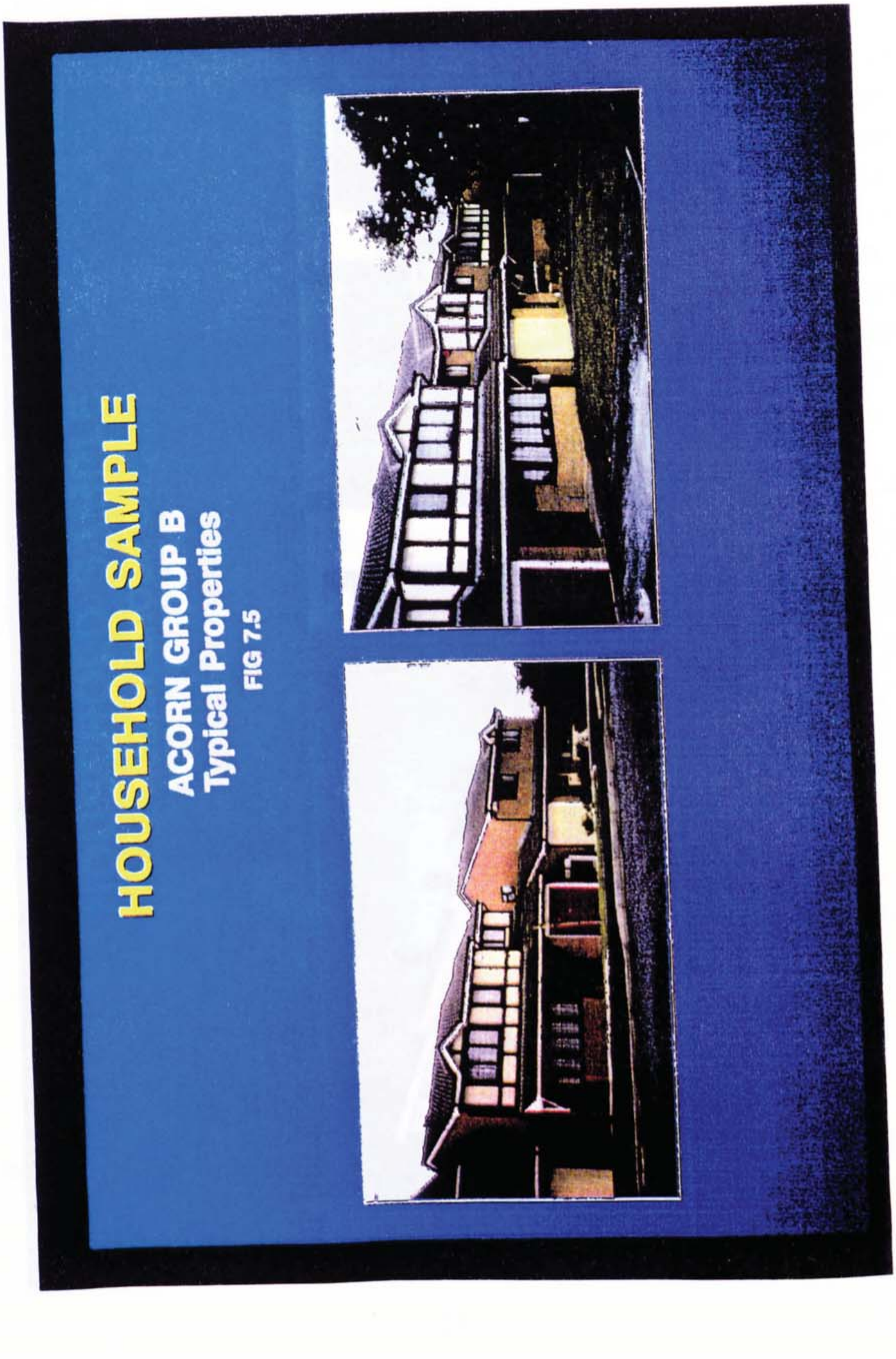
7.9.2 ACORN GROUP C : OLDER HOUSING INTERMEDIATE STATUS

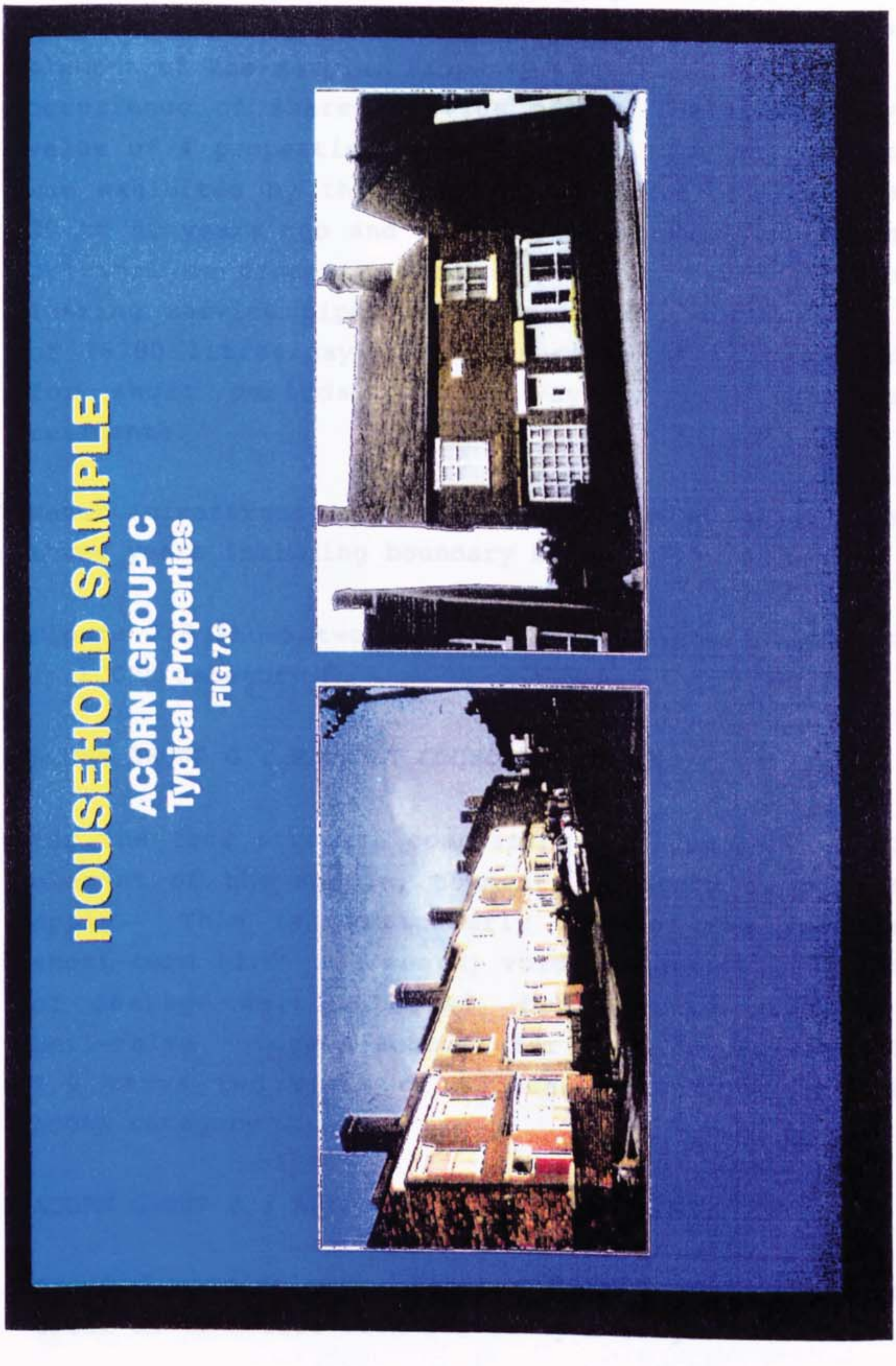
Two streets provided the locations for the 67 properties comprising this element of the sample. In street number 6, 31 connections served 35 properties and in street 7. 15 connections served 35 properties. This later street yielded the sample maximum of 8 properties served by one service pipe.

Both streets had received complete replacement infrastructure up to and including boundary boxes. Beyond this point, i.e. on property, all houses retained original service pipes. Comments regarding the potential for restriction are therefore similar to ACORN group B. In general properties were constructed more than 50 years ago. Two leakages had already occurred to property references 60 and 71 to the trial commencing. This equated to a loss of 3000 litres/day. Two void properties occurred at reference 61 and 83. Figure 7.6 shows two views of typical households included in ACORN category C.

7.9.3 ACORN GROUP E : BETTER-OFF COUNCIL ESTATES

Four streets provided the 51 houses comprising this element of the sample. Three streets contained council property of recent construction including boundary boxes and modern, separate, service pipes. The fourth, street number 11 contained 34 houses served by 21 connections. Complete infrastructure renovation had taken place in 1990. Previous comments concerning the potential effects of older service pipes apply. Group E yielded one property subject to a leaking ball valve, losing water at a rate of 1700 litres/day for 5 months and two instances of void property. Figure 7.7 shows two views of typical households included in ACORN category E.


HOUSEHOLD SAMPLE
ACORN GROUP B
Typical Properties
FIG 7.5


HOUSEHOLD SAMPLE
ACORN GROUP C
Typical Properties
FIG 7.6

7.9.4 ACORN GROUP F : LESS WELL-OFF COUNCIL ESTATES

Group F was represented by 160 properties located within four streets. As such it represented the largest single element of the sample. Property was characterised by total occurrence of shared service pipes. The highest average value of 4 properties per connection, for any one street, was exhibited by this sample. Construction was generally 30 to 50 years ago and all properties were served through original on-property service pipes. Five instances of leaking service pipes were identified, consuming a total of 16700 litres/day. The occurance of void properties, for short periods, was a way of life accepted by residents.

Water infrastructure renewals had occurred within the last three years including boundary boxes.

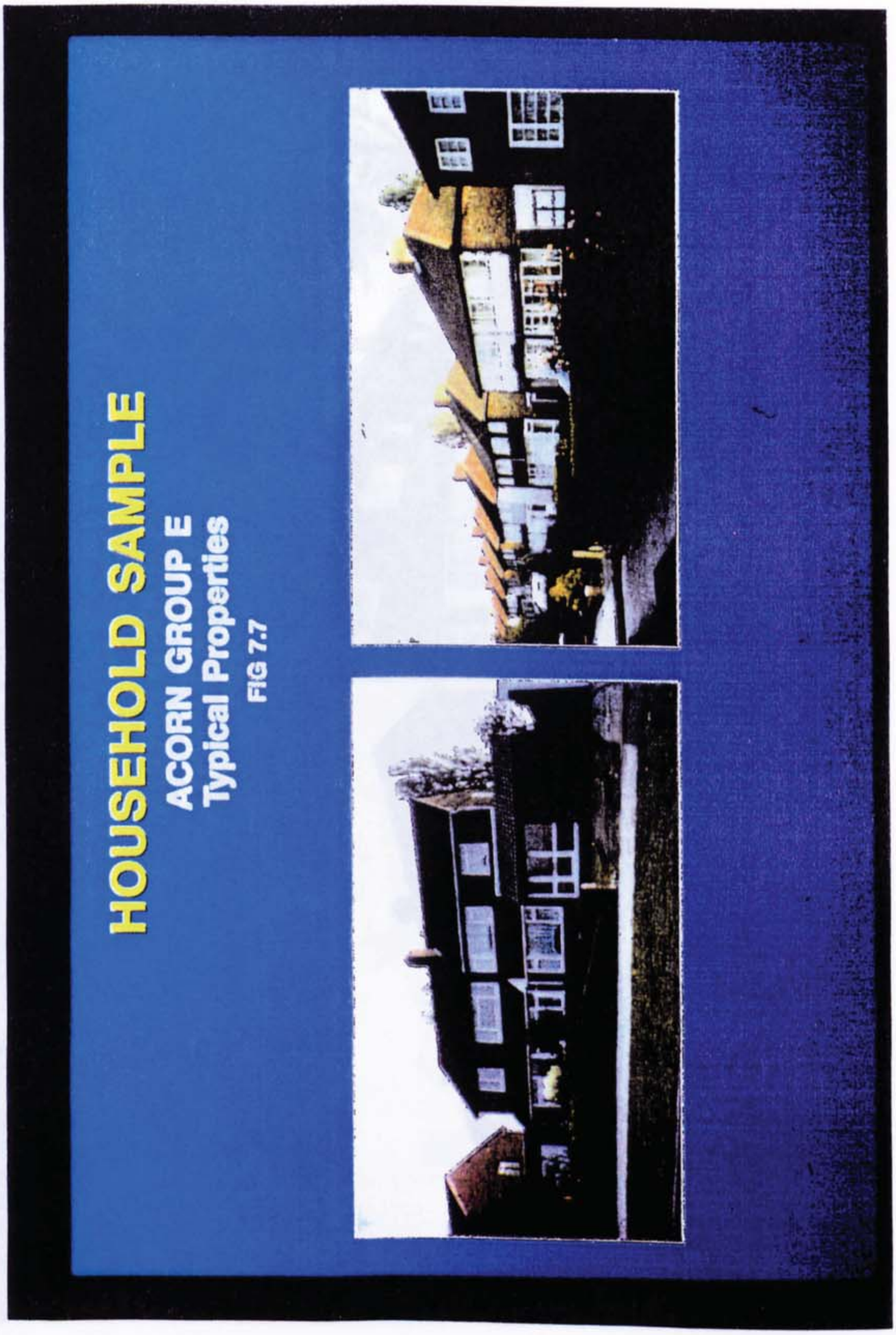
Figure 7.8 shows two views of typical households included in ACORN category F.

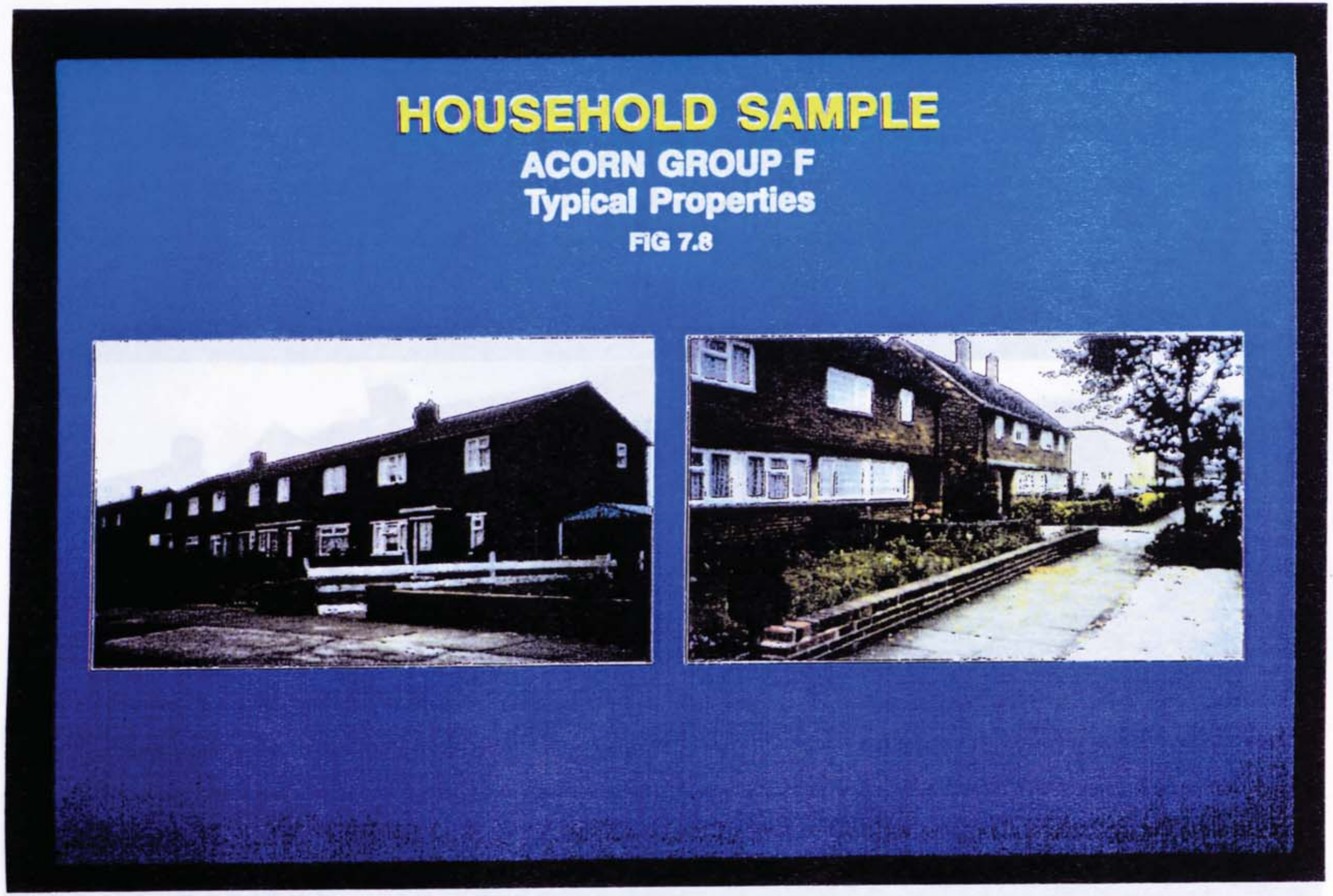
7.9.5 ACORN GROUP G : POOREST COUNCIL ESTATES

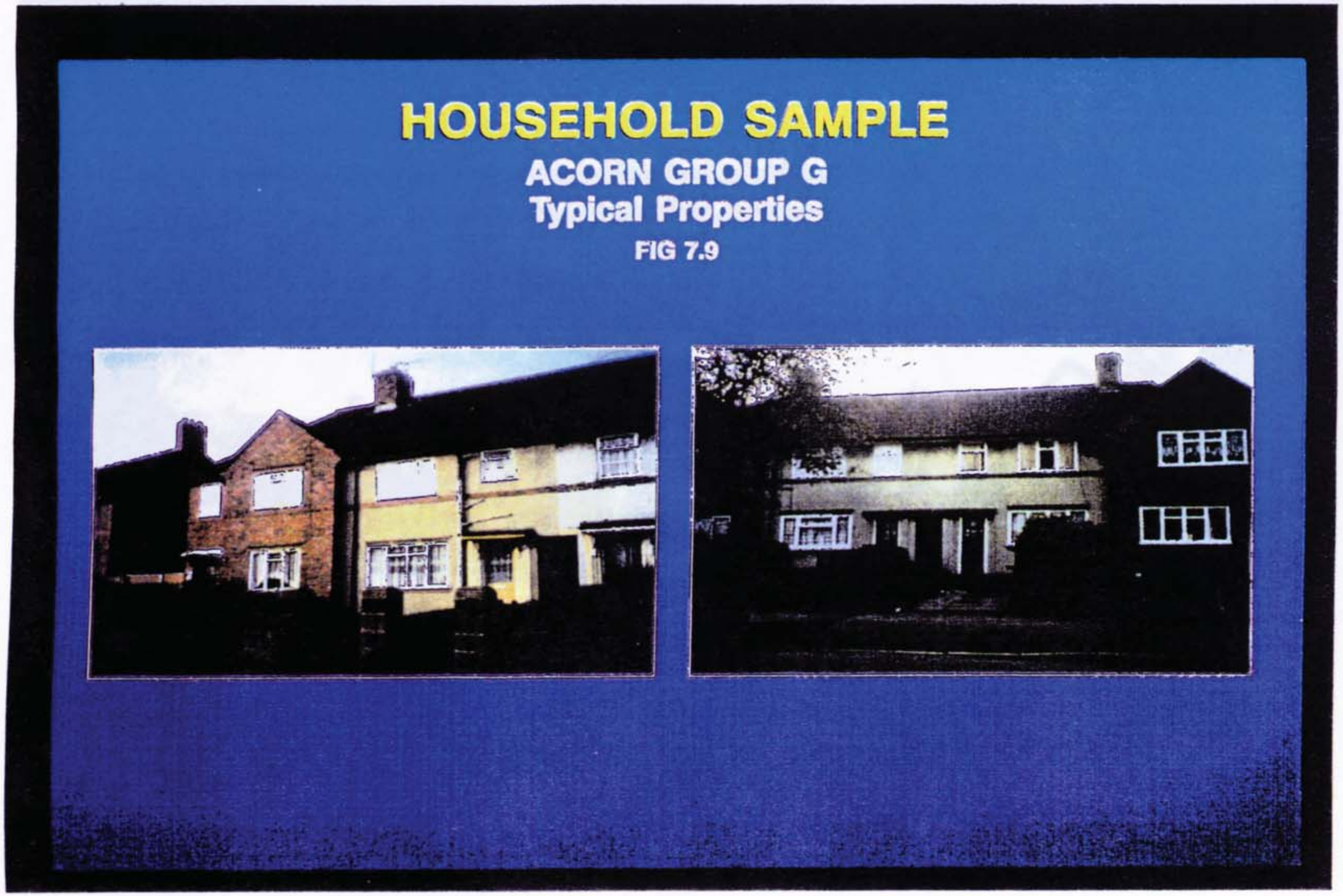
For the four streets, comprising 142 properties to this element of the sample, comments generaly as per group F apply. This is particularly true of the frequency of short-term (i.e. one month) void properties. 3 instances of leakage were detected, two service pipes and one ball-valve. Losses account for 4285 litres/day. Figure 7.9 shows two views of typical households included in ACORN category G.

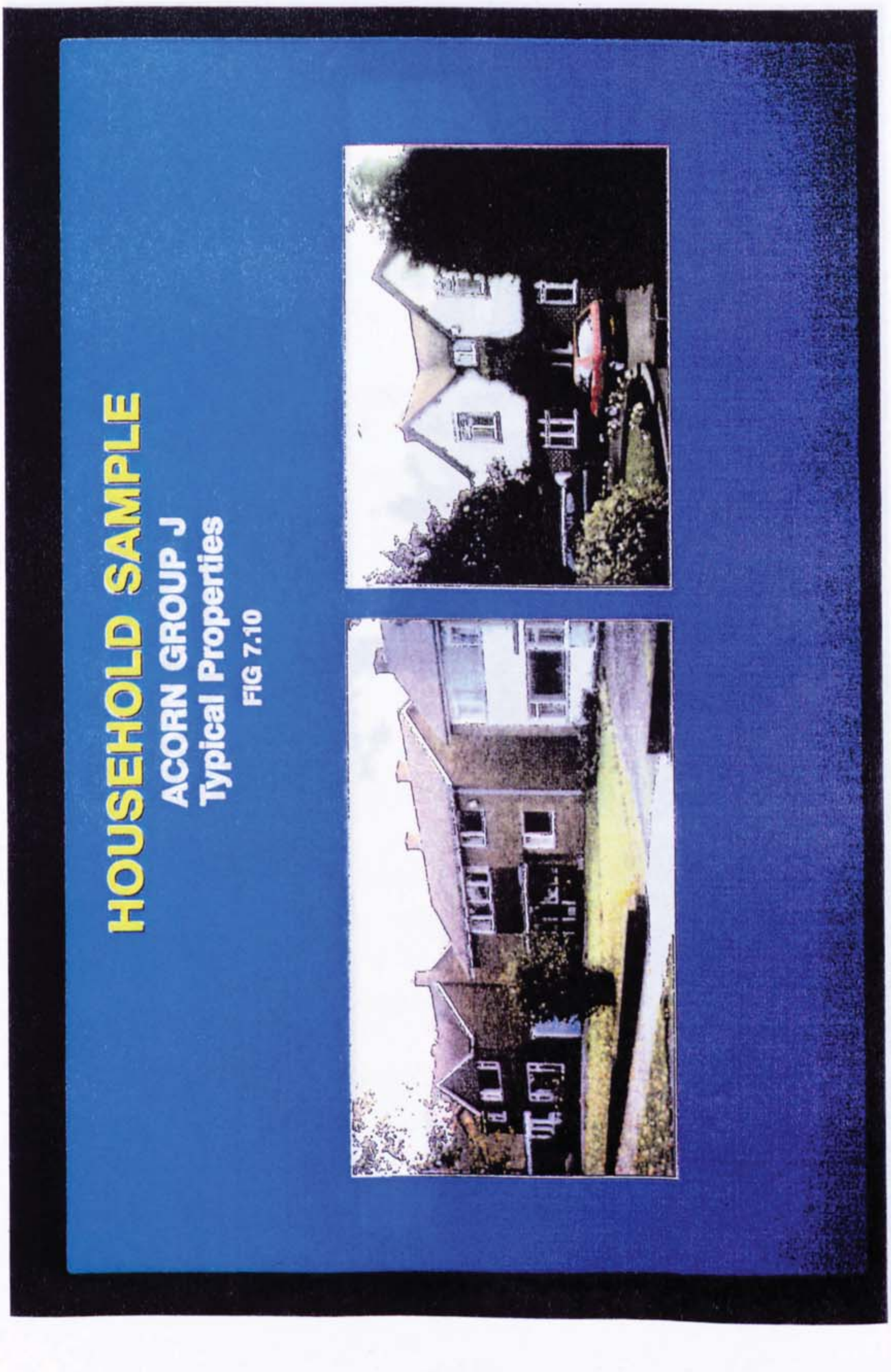
7.9.6 ACORN GROUP J : AFFLUENT SUBURBAN HOUSING

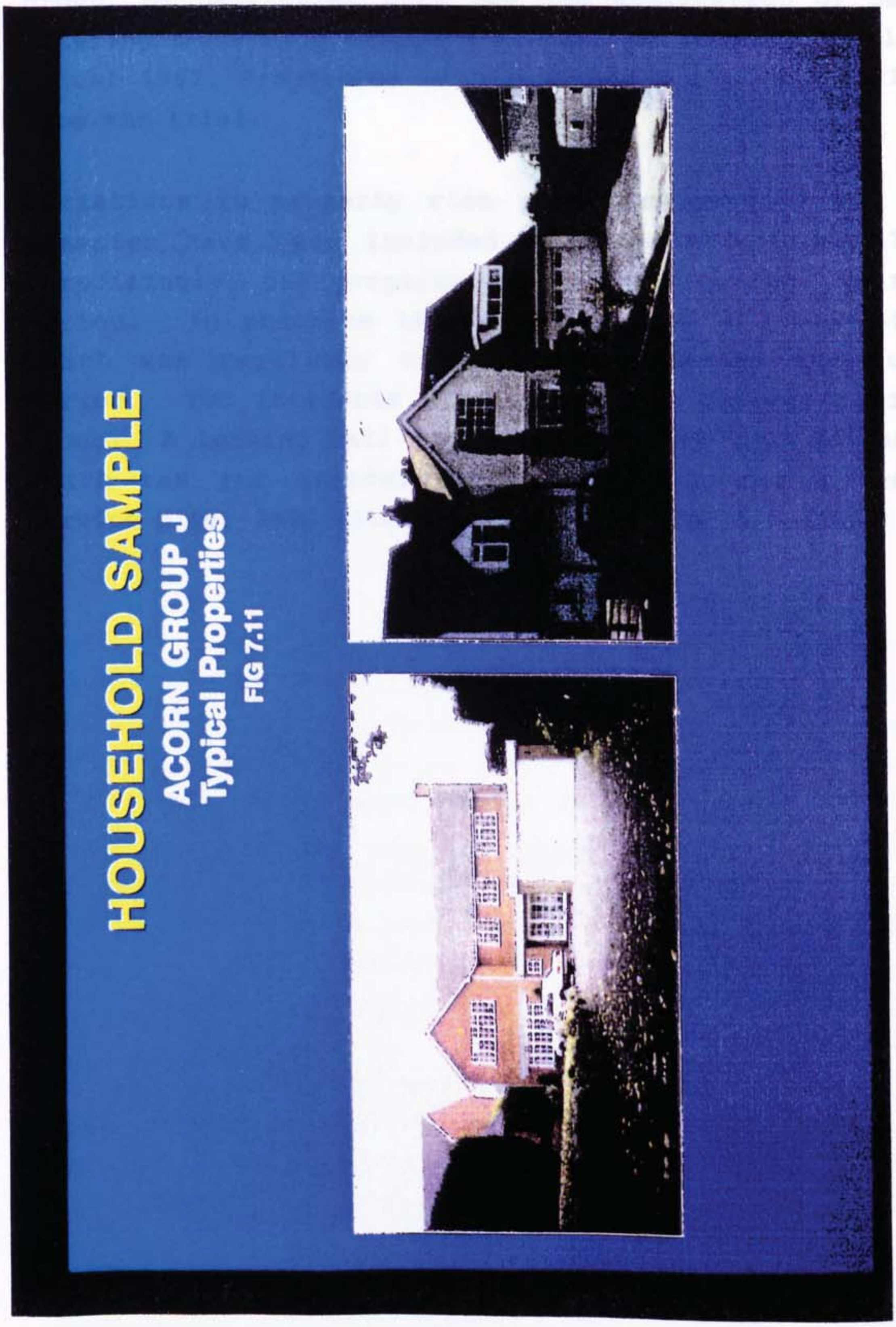
Group J samples were obtained from 4 streets providing a total of 40 houses each served by a single connection.


HOUSEHOLD SAMPLE
ACORN GROUP E
Typical Properties
FIG 7.7


HOUSEHOLD SAMPLE
ACORN GROUP F
Typical Properties
FIG 7.8


HOUSEHOLD SAMPLE
ACORN GROUP G
Typical Properties
FIG 7.9


HOUSEHOLD SAMPLE
ACORN GROUP J
Typical Properties
FIG 7.10


HOUSEHOLD SAMPLE
ACORN GROUP J
Typical Properties
FIG 7.11

The properties all exhibited the trappings of a high standard of living consistent with their inclusion in this group. Of particular note was the application of garden watering much in evidence at intervals between April and August 1992. Properties with swimming pools were excluded from the trial.

Variations in property size were considerable and four examples have been included as figures 7.10 and 7.11. Surprisingly, one property became void during the trial period. In practice this proved to be a "granny-flat" which was regularly only occupied during the summer period. Two incidents of leakage were detected for the group. A leaking ball tap accounting for 1500 litres/day which ran for approximately one month and a leaking service pipe, 3800 litres/day which ran for 6 months.

CHAPTER 8

THE DEVELOPMENT OF CONTINGENT VALUATION METHODOLOGY FOR METERED CUSTOMERS

8.0 INTRODUCTION

Unlike unmetered households, commercial and industrial consumers, jointly referred to as trade customers, pay for water by volume. Thus it can be seen that such customers are directly able to influence consumption and hence cost of water services .

Historically it is likely that controling water usage on site was not an issue, with either the customer or utility, due to relative cheapness of water and abundance of supplies.

Both of these situations have, however, been subject to considerable change in recent years. Whilst water is still a low cost commodity, relative to other utility providers, trade consumers are more aware that savings can be made. This reflects not only in the bill for potable water but also the associated charges levied for sewage and effluent disposal. The realisation that reduced water consumption can very often also contribute to reduced energy costs, ie heating and pumping, provides a further stimulus particularly for large users.

From the utilities perspective, environmental concerns coupled with a gross increase in consumption are beginning to equate to resource shortfalls. Thus conservation has the potential to assume a role in resource management.

Metered customers represent a much wider spectrum of consumption than the unmetered household sample. For South Staffordshire Water, metered usage ranges from 0 to considerably in excess of 5 million litres per day for individual sites.

Consumer groups range from households to power stations. Occupied sites range from a few square metres to several square kilometres. Service pipes range from small bore domestic size to dedicated mains running for many kilometers inclusive of pumping stations.

Given such a range and the fact that metered customers have an existing incentive to conserve water a different approach was developed to ascertain the conservation potential of trade customers.

Trade customers would be approached and interviewed in a formal manner with questions designed to obtain data relating to variables influencing consumption. A methodology described as "contigent valuation" would be used as one basis for determining conservation potential. That is customers would be asked to identify a probable reaction to proposals concerning water supplies to their premises.

Two other measures would be employed to cross-reference perceived responses. These are an assessment of historic water usage related to price increases, and an assesssment of variables likely to be influencing consumption. This data would then be analysed to determine potential for conservation when contrasted with customers having similar descriptive characteristics.

8.1 VARIABLES

Section 3.3 considered variables likely to influence consumption. A distillation of those factors specifically relating to trade customers is shown as table 8.1. Three collective categories were developed to represent an overview of influencing variables. These are:-

1. CUSTOMER AND PHYSICAL CHARACTERISTICS.
2. SEASONAL CHARACTERISTICS AND.
3. CONSERVATION POTENTIAL.

The methodology developed with reference to each category is discussed in the following sections.

8.2 CUSTOMER AND PHYSICAL CHARACTERISTICS

A total of 9 variables were identifed relating to customer characteristics. Of these, four represented customer class ie domestic, commercial or industrial properties. The use

of water once on site could be for any of these purposes and indeed this is likely to be normal. For example all sites will use water for domestic purposes ie cooking, washing and toilet flushing.

A measure indicating the properties prime purpose was required with detail regarding water usage collected separately. Standard Industry Coding (SIC) was selected for this purpose based upon the classification system in widespread use throughout the water industry. Thus customers could be identified as for example metal manufacturers, hospitals or educational establishments. For research purposes this provided a basis for comparative assessment between customers within the same groups. Table 8.2 shows the SIC descriptions and the numbers of customers for the Companys area of supply.

An examination of company records for 1988 indicated that two hundred customers, from a base of 19,139, consumed more than 40% of all metered water. The manageable size of this group and the importance of their existence led to a sample of 100 being included in the survey. The group was referred to as "Major Customers". This group represented the findings expressed by Smith (Section 2.6.4) regarding the top 100 customers using 35% of water consumed from North West Water.

CONSIDERATION OF VARIABLES INFLUENCING METERED CUSTOMERS

TABLE 8.1

VARIABLE	OUTPUT VARIABLE MEASURE
CUSTOMER AND PHYSICAL CHARACTERISTICS*******	
Consumer Class Domestic Commercial Industrial	S.I.C
People using site	Equivalent Fulltime People Changing Staffing Levels
Relative Size	Annual Production Output Annual Turnover Changing Turnover Site Area
Cap Invest	Years on Site
Plumbing Style Modification Potential Plumbing Condition Property Design Plant Type	Years on Site
Water Uses	Cooling Washing Process Domestic Storage Environmental
Demand Potential	Nr Supplies Size Supplies
SEASONAL************	**SEASONAL******************
Seasonal Variation	Seasonal Production
Time Related Variable	Shift Working
Time Related Variable	Working Patterns

Sheet 1

CONSIDERATION OF VARIABLES INFLUENCING METERED CUSTOMERS

TABLE 8.1

VARIABLE	OUTPUT VARIABLE MEASURE
************ CONSERVATION	POTENTIAL ***************
Price Sensitivity	Know Bill Water Price
	Last Appeal
Potential Savings	Conservation Measures
Conservation Sensitivity	Pressure Volume
OUTPUT VARIABLE ******	OUTPUT VARIABLE **********
Annual Consumption	Water Used &
Annual Water Bill	Cost
Production Measure	Annual Output

Sheet 2

The remaining 18939 customers, who in total accounted for in excess of 50% of metered water, represented an important and diverse group, including housholds who had opted for metering. A sample of 100 customers was also selected from the complete metered customer database including major customers, using a random number generator applied to 1988 meter account records. This group is referred to as the "Sample of All Metered Customers".

The number of people using a site was deemed important (8.6.4) as this was assumed to relate directly to domestic usage of water and indirctly to the size of the site. For commercial properties, such as banks or offices, obtaining this data was uncomplicated. For institutions such as hospitals schools and those sites operating on a shift system equivalent numbers of people were obtained. Thus for a site working three shifts a day with 50 people per shift the number of people recorded was 150.

To aid comparison three factors were obtained relating to the scale of business. A measure of annual production output related a factor specific to industrial grouping. Thus one steel mill could be compared to another. In practice enourmous disparity existed within, for example, the SIC grouping of metal manufacturers. Ranging from output measured as castings of 10000 tonnes per year for one concern to 11 tonnes of silver plating for another.

Commercial or households were, in most cases, unable to provide data to answer this question but tended to relate size of business to people or turnover.

The second factor for comparative purposes was turnover. In practice, however, this proved very difficult to obtain accurately with customers unwilling to divulge such information. The majority of businesses surveyed were privately owned and not registered as companys.

METERED CUSTOMER BASE BY SIC CATEGORY

SOUTH STAFFORDSHIRE WATER PLC (1988/89)

TABLE 8.2

REFERENCE	DESCRIPTION	NO. OF SITES	% OF TOTAL
MANUFACTURING			
A	Metal Fabrication	470	2.4
B	General Engineering	980	5.1
C	Iron & Steel	138	0.7
D	Breweries	38	0.2
E	Chemical & Allied Industries	77	0.4
F	Food & Drink	249	1.3
G	Mining, Bricks & Cement	153	0.8
H	Sundry Trade	780	4.1
SERVICE			
1	Electricity Generating	19	0.01
2	Educational	950	5.0
3	Agricultural (Exc. troughs)	265	1.3
4	Commercial/Public Service	1460	7.6
5	Bulk Supplies	38	0.2
6	Hospitals	84	0.4
7	Sports & Recreation	711	3.7
8	Launderies	120	0.6
9	Sundries Non-Trade	320	1.7
10	Building Water	0	0
Z	Domestic Meter Options	1826	9.5
Y	Commercial Meter Options	8047	42.0
X	Mandatory Commercial Options	2414	12.6
		19139	99.61

It was not possible therefore to obtain details, particularly for minor customers, from public records. Further, for those public records consulted there was generally no information relating to the specific sites in question. Rather the normal practice was to report statistics, including turnover for entire businesses.

The solution used was to group turnover into bands and ask customers which applied to themselves. This approach resulted in a much greater, although far from complete, exchange of information. In practice the data collected for the "All Metered Customers Sample" was so poor as to be rejected at an early stage.

The selected bands were refined with experience to be:-

BAND	ANNUAL TURNOVER
1	£0 TO £1/2M
2	£1/2 TO £1M
3	£1 TO £5M
4	£5 TO 10M
5	> £10M.

The third factor with respect to a measure of scale was the physical site area (2.6.4). Customers were interviewed on the basis that questions were related to a specific site and not, for example, to the entire UK operations.

Site size was obtained from interview and by reference to Ordnance Survey maps held by the Company as part of its statutory assets register and, in all cases, by visits to site.

As discussed in section 3.3.3 the number of years customers had been on that site was taken as a variable potentially representing a number of secondary factors such as capital investment. It was assumed that if such a relationship existed those businesses newer to a site would be more likely to have invested in modern plant and equipment .

Also as discussed in section 3.3 the uses of water were considered significant. The questionnaire, used to formalise the interview, was therefore developed to generate information on which of the following applied:-

COOLING
WASHING
PROCESS
DOMESTIC
STORAGE
ENVIRONMENTAL

As a measure of demand potential the numbers and size of supplies to each site was recorded. The maximum number of connections to a single site was noted at 13. When raised at interview stage multiple connections were often required for flexibility of supply rather than to meet peak demand requirements. The variable was retained but will not be carried forward for analysis.

8.3 SEASONAL CHARACTERISTICS

Trade customers were to be interviewed on a one off basis. Therefore unlike the methodology adopted for households consumption, which was assessed over a series of periods, trade consumption could not be related to seasonal or climatic changes.

The contingent valuation approach, adopted for trade customers, was to present questions which the interviewee could relate to experience for that site. The questions included a specific reference relating to seasonal working patterns but also took the opportunity to expand the theme. Additional enquiries were made to verify working patterns. For example was shift work routine.

8.4 CONSERVATION POTENTIAL

The questions regarding the conservation potential of a specific site were developed around three differing approaches. Great detail was often recounted which, on a number of occasions, yielded relevant information.

The interview was developed to obtain answers requiring little speculative thought early on. Subjective questions were then asked to determine the respondents knowledge. What was the annual bill for water services to that site. Replies were correlated with actual bill values to measure accuracy. Perception of water service value for money was then pursued to obtain the respondents assessment.

Customers were then asked three contingent valuation questions designed to directly assess the conservation potential of that site. As a bridge between the knowledge and these subjective questions a conversational approach was adopted asking if:-

> Q: customers could remember voluntary requests to save water in the past?

Out of 200 interviews only 2 people had any recollection of such appeals.Respondents were then asked if:-

> Q: such a request was repeated how much, in pecentage terms, could that site reduce consumption?

In a similar manner customers were asked:-

> Q: if they had experienced any loss of supplies and what action they would take in such an event? The question was expanded to determine if the site could be supplied at a reduced pressure.

Referring to costs, the customers reaction to various price increases was tested.

Q: At what stage would increases, ahead of inflation, stimulate savings?

Analysis would allow price projections to be measured against revenue.

Customers were then asked;

Q: what steps would they, or indeed had they, taken to reduce water consumption?

Suggestions were made relating water conservation to:-

1. Re-cycling water.
2. Using/purchasing water efficient plant.
3. Regularly monitoring consumption.
4. Consumption reducing devices and
5. Use or availability of alternative sources.

Finally respondents were asked to report the percentage levels of bill value for each of the utilities supplying the site.

8.5 CONTACT WITH THE CUSTOMERS

All 100 of the major customer sample were personally interviewed, face to face, at their place of business. The quickest interview took 40 minutes and the longest 6 hours.

Initial contact was made over the telephone with a few questions being asked to confirm contact with the correct individual. A summary of my requirements was given during the telephone conversation and an appointment made to the respondents convenience.

A copy questionnaire was mailed to the individual with a second copy being presented at interview to aid as a refresher and to avoid embarrasing the respondent.

Invariably customers would be hesitant at interview commencement but gradually warm to the theme. In most cases information was required by the respondent regarding technical issues of water supply or equipment. This was freely given either at interview or at the soonest opportunity afterwards.

When possible each of the 100 minor trade customers were also treated in the same manner. However twenty three smaller metered customers, particularly householders, refused a personal interview. In these cases questionnaires were forwarded for completion. They were then either returned without comment or if not forthcoming customers were subject to a further telephone conversation. In these cases it was normal for outstanding questionnaires to then be completed over the telephone.

With either group queries were pursued over the telephone or if the customer preffered at their address.

The development of the questionnaire continued during the early stages of interview. Information was translated from earlier to subsequent forms with, if necesarcy, reference back to the customer for verification.

Major Customers were interviewed over the 2 year period April 1988 to April 1990. Minor customers were interviewed over the 15 month period November 1988 to February 1990.

8.6 QUESTIONNAIRE DEVELOPMENT

Initial assessment of variables allowed the production of a questionnaire which proved far to detailed and complex in use.

A matrix of water consumption, site employment, turnover, profit and capital expenditure for each of the years 1980 to 1988 asked for confidential and detailed information which customers either would not release or did not know.

Several interim adjustments were made and tested on individuals outside of the identified sample. The original and final versions of the questionnaire are included as Appendix C. A number of revisions to the questionnaire occured so that the data was recorded to suit analysis.

It must be remembered that the document was developed to be completed by myself during an interview. This assisted in ensuring consistency of reporting.

When the same questionnaire was applied to the minor customer group, it generally requested information that was not applicable. This statement is particularly true for households and the household sized commercial businesses comprising the bulk of this group. A simplified questionnaire was developed to compliment the major trade document and is also included in Appendix C.

Details of the two samples, results of the analysis and formulation of representative models follow in Section 9.

PART FOUR

DATA ANALYSIS, FINDINGS AND CONCLUSION

CHAPTER 9

ANALYSIS OF THE METERED CUSTOMER SAMPLES

9.0 INTRODUCTION

Two separate metered customer samples were extracted, at random, from records. The first was a selection of 100 sites from the Companies top 200 annual consumers (8.2). These were entirely non household and represented predominantly manufacturing industries. The second sample represented a cross section of all metered customers including both major customers and households (8.2). The samples are termed the "Major Trade Sample" (Sections 9.1 to 9.5 inclusive) and the "All Metered Customer Sample" (Sections 9.6 to 9.8 inclusive). Subsequent testing was undertaken on two further samples which are referred to as Phase II "Major Trade Sample", etc.

This Chapter describes the two samples independantly with respect to characteristics, price sensitivity and conservation potential. The data is analysed, separately, and developed to create explanatory models. The Chapter finishes with conclusions drawn from the consideration of both sample models.

9.1 DESCRIPTION OF THE MAJOR TRADE SAMPLE

Half of the entire population of South Staffordshire Water's major trade customer base was included in the research. This group represented the 200 largest water consumers, in 1988, when the study commenced. Each account in this group receives bills, for water services, on a monthly basis.

In practice the original group of 100, included 7 customers who, during the year, had reduced site consumption to less than 1000m3/ annum. Subsequent discussions demonstrated this was due to rationalisation or enforced closure. These sites were removed from the analysis. A secondary factor was the perogative exercised by four customers who proved reluctant to divulge information. As a consequence the final sample comprised 89 customers with consumptions ranging from 1000 to 627000 cubic metres per year. Average annual consumption for the group equated to 84000 m3.

The split by SIC code for the final major customer sample was:-

CODE	DESCRIPTION	CUSTOMERS
A.	METAL MANUFACTURERS	24
B.	GENERAL ENGINEERING	14
C.	IRON AND STEEL	14
D.	BREWERIES	4
E.	CHEMICALS/ALLIED IND.	6
F.	FOOD & DRINK	7
G.	MINING/BRICKS/CEMENT	4
H.	SUNDRY TRADE	8
1.	ELEC. GENERATING	1
3.	AGRICULTURAL	1
6.	HOSPITALS	7
	SAMPLE SIZE	89

Less than half of the sample yielded usable output measures. Only three units of measure were retained for analysis. Of these, tonnes/year was the most frequent being quoted for SIC codes other than breweries, milk and drink manufacturing, hospitals and electricity generating. For comparison, when necessary, volume outputs have been converted to tonnes/year. Such comparisons were not however feasible for hospitals or prisons were production units were taken as numbers of beds or inmates. In total 36 cases are complete with an output measure of tonnes/year and 7 with patient/inmate beds.

For the 36 cases complete with output in tonnes/year, the mean value was 17752, max 80000 and min 182 tonnes/year. In practice, these values are considered meaningless due to the variation in process requirements and units of production output. For cases reporting beds the mean value was 449/site. Due to the poor quality of this data, the variable was not carried forward for analysis.

Figure 9.1 shows that 60, out of the 89 major customers in the sample, had turnovers, for the sites in question, exceeding £10M. The lack of variation in the range, due to the questions banding (8.2) found necessary at interview is considered to have significantly undermined its potential as a factor related to water consumption.

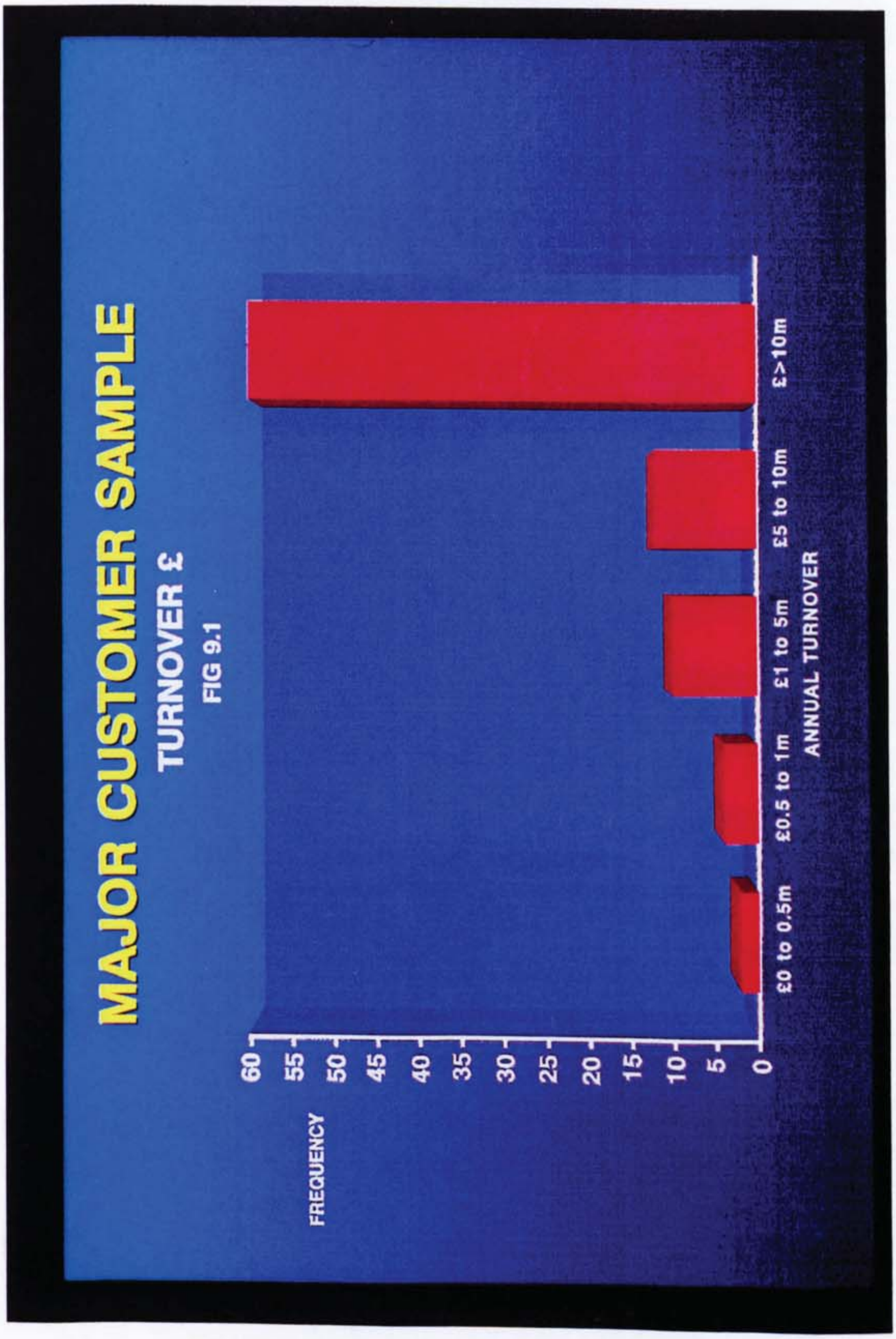
Figure 9.2 details the number of people on site. For hospitals and prisons this excludes patients and inmates. The mean value was 378 people with a range of 11 to 2000. 30 sites occurred with occupancy falling into the range of 100 to 300 people.

Mean annual water consumption, for the period ending March 31st 1987, was 83.6 Ml. The largest consumer in the sample received 627 Ml and the smallest 1 Ml. 75 sites consumed less than 125 Ml in the year, Figure 9.3.

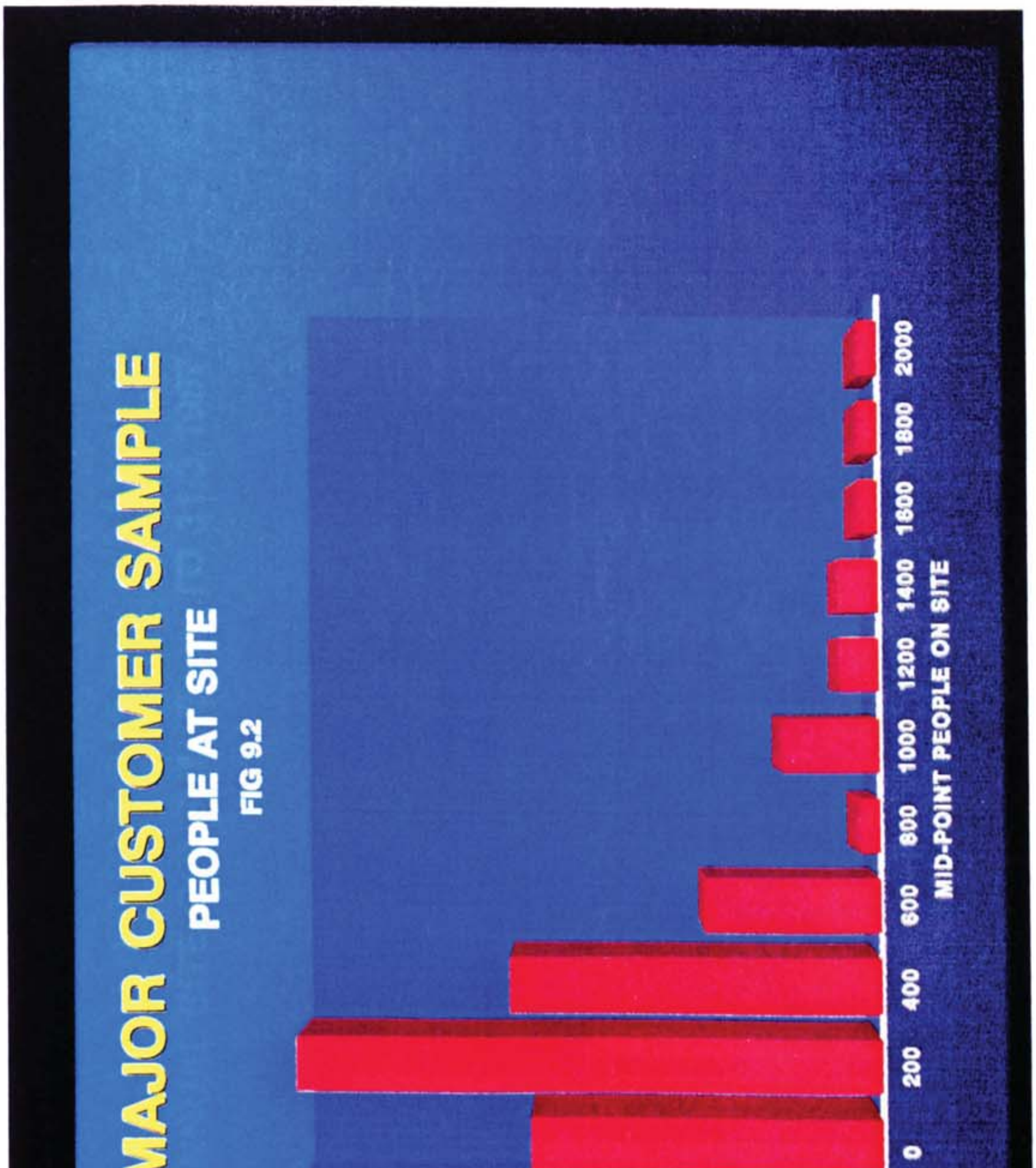
None of the customers interviewed as a part of this sample had occupied the site for less than 7 years.

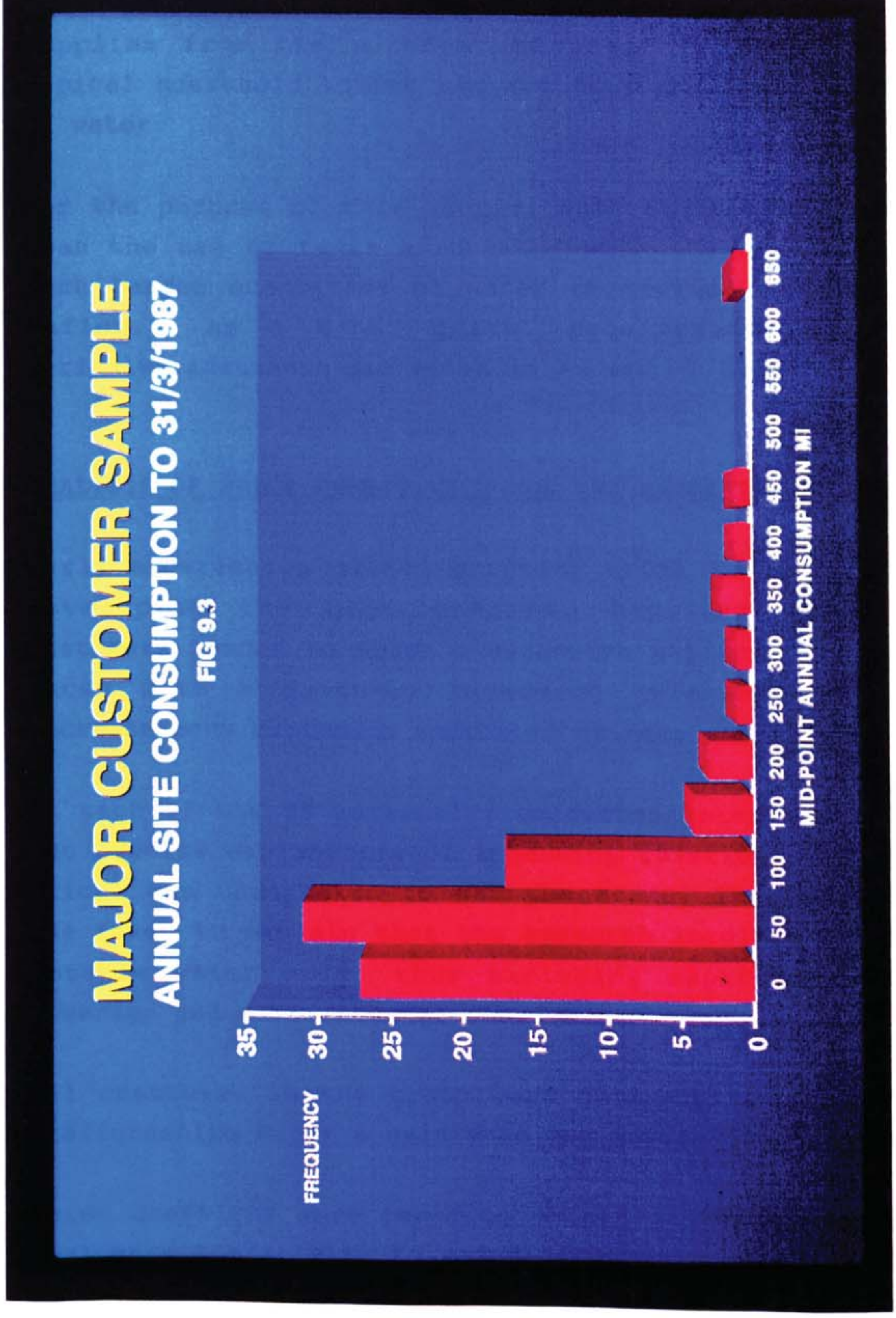
In-fact 82 cases had been at current addresses in excess of 10 years. The longest declared occupation of one site was 105 years for a metal manufacturer.

As expected all sites reported utilisation of water for domestic purposes including, for example, toilet flushing. This variable was therefore common to all cases and was removed from the analysis. At interview 49 sites declared no provision for bulk water storage. Cross checking with meter agreements and plumbing records demonstrated, however, that this was patently incorrect. Repeat visits were undertaken to verify discrepancies. All 89 sites did contain bulk storage facilities. This variable was therefore also excluded.



MAJOR CUSTOMER SAMPLE
TURNOVER £
FIG 9.1
FREQUENCY
60
55
50
45
40
35
30
25
20
15
10
5
0
£0 to 0.5m
£0.5 to 1m
£1 to 5m
£5 to 10m
£>10m
ANNUAL TURNOVER


MAJOR CUSTOMER SAMPLE
PEOPLE AT SITE
FIG 9.2
FREQUENCY
0
5
10
15
20
25
30
0
200
400
600
800
1000
1200
1400
1600
1800
2000
MID-POINT PEOPLE ON SITE


MAJOR CUSTOMER SAMPLE
ANNUAL SITE CONSUMPTION TO 31/3/1987
FIG 9.3
FREQUENCY
35
30
25
20
15
10
5
0
0 50 100 150 200 250 300 350 400 450 500 550 600 650
MID-POINT ANNUAL CONSUMPTION Ml

The experience promted all subsequent interviews to conclude with a factory inspection to verify data.

Note on bulk storage.

The majority of customers use some form of water storage, i.e. a temporary holding tank which separates incoming supplies from the point(s) of usage. For example a typical household toilet cistern is a small volume store of water.

For the purpose of this thesis, bulk storage is taken to mean the use of tanks associated with the need to store much larger quantities of water to provide an emergency buffer. As a broad guide, requirements for fire sprinkler insurance are often in excess of 50 m^2.

9.2 ANALYSIS OF PRICE SENSITIVITY FOR THE MAJOR TRADE SAMPLE

Early experiences gained pursuing trial samples, whilst developing the questionnaire, had indicated that customers tended to adopt a defensive attitude. Thus when faced with a question regarding tolerance to price increase many customers indicated extreme sensitivity.

At each of the 89 personally conducted interviews, brief but precise explanation of impending questions, regarding price, was undertaken to set the scene. The opportunity was taken to explain that the research involved bills for potable water only, thus excluding separately levied sewerage and environmental charges.

All customers in the group were entirely aware of South Staffordshire Water's existence and nature of business.

Three questions were asked to obtain an insight into the customers sensitivity to price: Customers were questioned to determine a coarse measure of perceived value for money. Was the bill for water service regarded as low, acceptable or high.

Customers were then asked what their bill for water services was, for current or recent months. This was compared to actual bill values for assessment. If stated values were within 30% of recent bills the respondent was subsequently marked as having given a correct reply.

The interview proceeded by applying a contingent valuation approach to pricing for water. Respondents were asked to react to a scenario of percentage price increases in excess of inflation. The purpose was to assess which relative level of increase would trigger customers to conserve water.

To obtain a measure of actual response, rather than imagined, customer records were examined to determine factual reaction. This was particularly true of the year during which the interviews were undertaken, when a 19.5% increase was levied. The General Index of Retail Prices for the same period equated to 9.5%.

Relating results in the order asked, revealed that 44% of customers regarded the bill as high whilst 5% stated that the bill was perceived as low. Overall 46 (52%) customers from the 89 taking part expressed satisfaction. In total therefore 50 customers (56%) thought the level of charges for potable water services represented acceptable or good value for money.

When pursued to the subsequent stage, analysis revealed that 20 from 89 did not know what their bill, for water services was. Of interest, despite this fact, not a single respondent hesitated in answering the question regarding their perception of value for money. A cross Tabulation of "knowledge of bill value" and "perception of value" shows:-

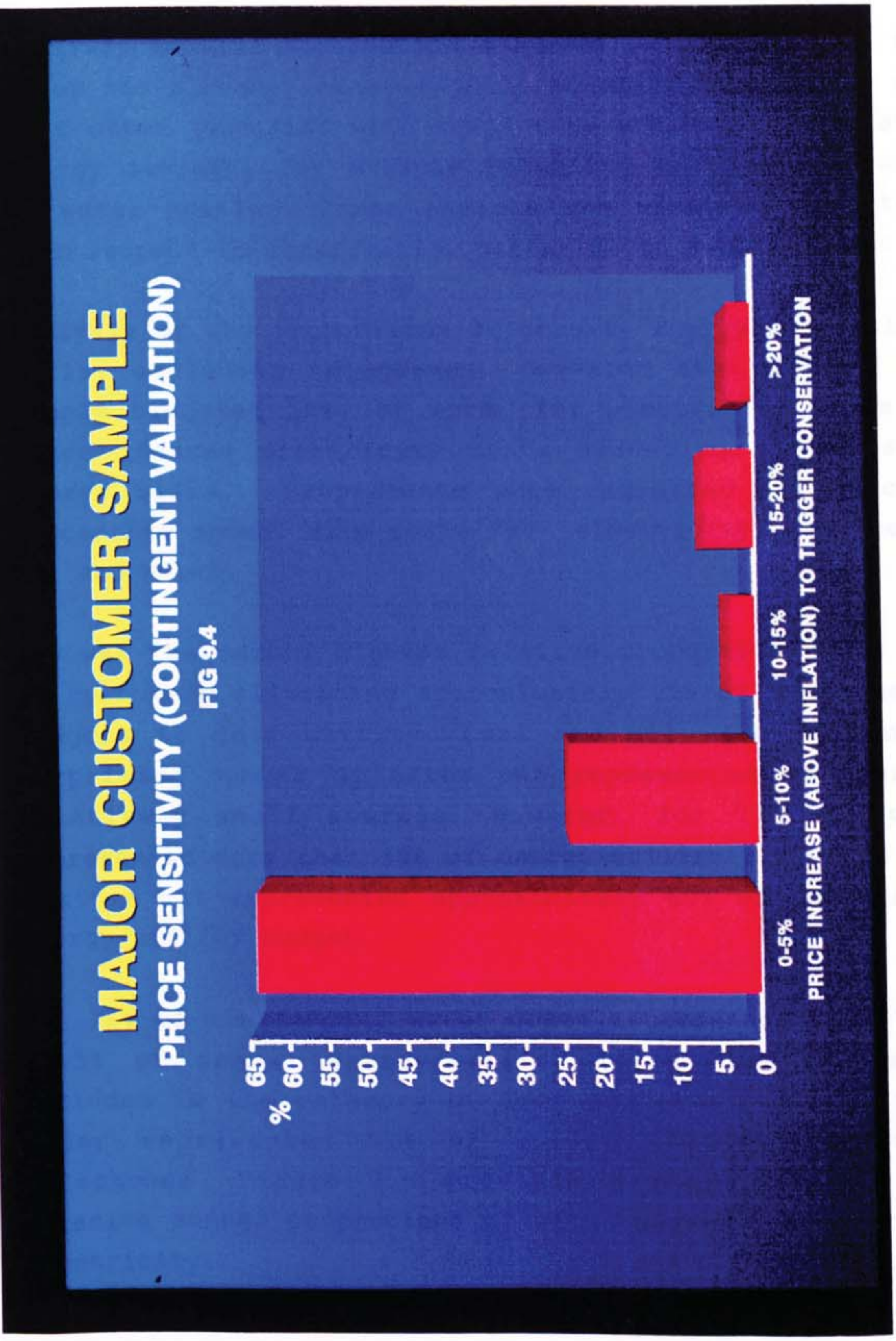
		REGARD WATER CHARGES			
		HIGH	OK	LOW	ALL
	NO	5	15	0	20
KNOW BILL £	YES	34	31	4	69
	ALL	39	46	4	89

Thus it can be seen that 15 respondents indicated satisfaction without knowing the size of the water bill whilst 5 declared that bills were too high, representing poor value, without actual knowledge.

Response to the question of conservation trigger levels, with respect to price, was probably predictable. 57 customers stated that any increase above inflation would generate voluntary savings on their part. Similarly 21 would react to 5-10% increases, 3 for 10-15% and 5 for 15-20%. 3 customers stated that charges in excess of 20% would be absorbed before attempting to react by conserving water. Of particular interest two of these three, stated their inability to react beyond conservation measures already in force. Figure 9.4.

In practice, none of the customers in the sample consciously reduced consumption with respect to the 19.5% price increase, 10% ahead of inflation, imposed for the year 1989/1990. This was determined by examining individual customer records for the year in question and discussing the issue during interview. However three customers in the group completely closed down operations at specific sites within 12 months of the interview period. No contact was made with these customers to determine if water price increase played any part in such decisions.

A number of customers indicated that despite considerable absolute annual bills for water these charges were considered to be relatively small when compared to other utility or fuel costs. In this respect major customers, in general, expressed a pragmatic preference for percentage savings to utility bills other than water.


MAJOR CUSTOMER SAMPLE
PRICE SENSITIVITY (CONTINGENT VALUATION)
FIG 9.4
%
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0-5%
5-10%
10-15%
15-20%
>20%
PRICE INCREASE (ABOVE INFLATION) TO TRIGGER CONSERVATION

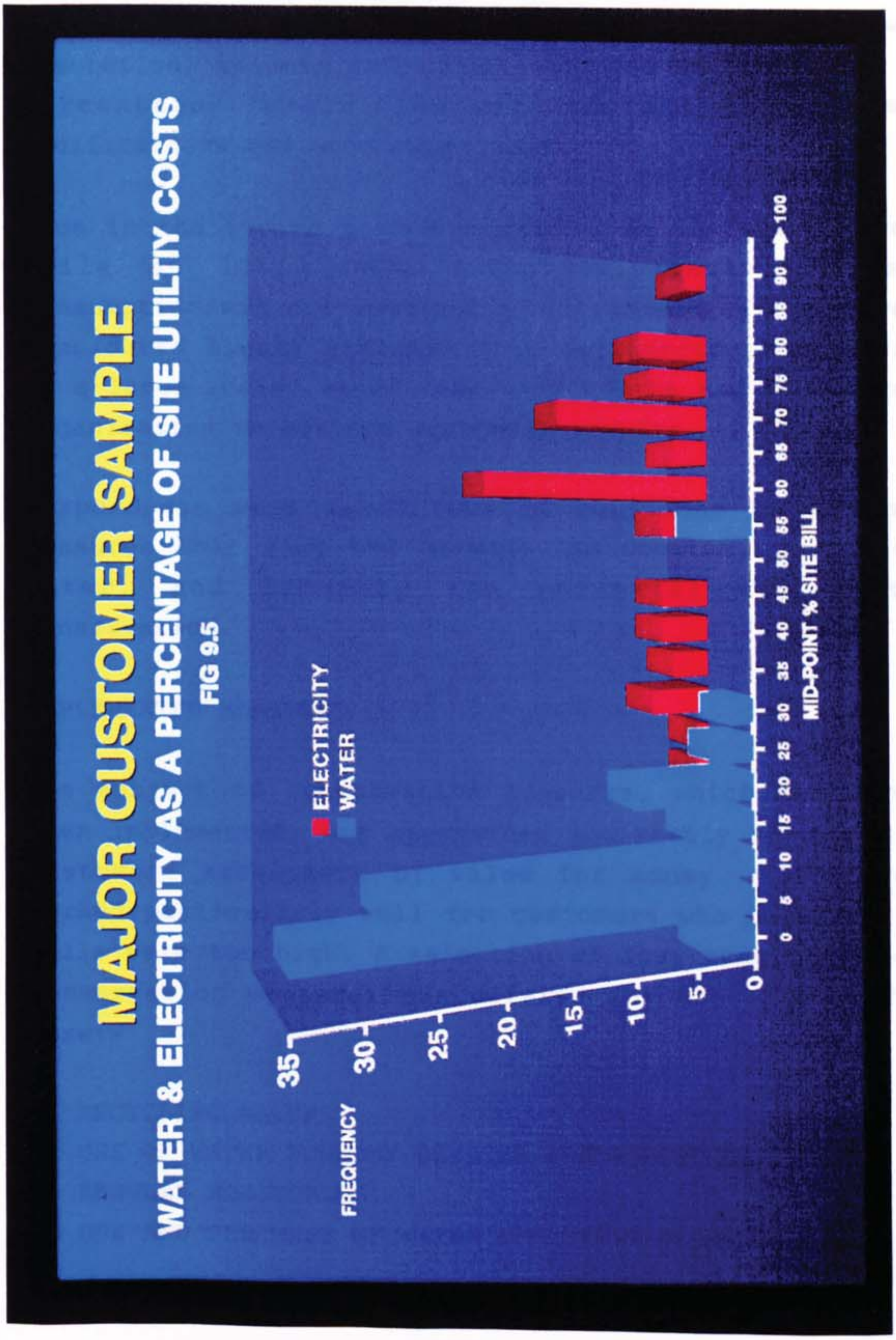
Most customers indicated that whilst water bills continued to represent fractions of site costs, conservation efforts would be directed elsewhere.

Contrary to this observation a number of customers in the group had already taken steps to conserve water. This was most often justified with respect to achieving associated energy savings; for example recycling to minimise costs of water heating. These aspects are analysed in detail with respect to conservation potential in section 9.3.

Analysis of the proportions of on-site energy and utility bills, excluding telephones, revealed that 80% of the sample budgeted 50%, or more, for electricity costs. 2 sites incured electricity costs exceeding 90% of site energy bills. Respondents were requested to indicate percentage annual site costs for electricity, gas, coal, oil and water.

Gas was the second highest relative proportion with 50% of customers allocating approximately 25% of site energy budgets to this utility. Coal and oil were used on a surprising number of sites but represented an overall relatively small average. However, for 7 sites coal represented more than 30% of energy/utility bills and for 3 sites oil represented approximately 60% of the annual energy/utility budget.

For 76% of the sample, water costs represented less than 12.5% of annual energy/utility bills. One customer, included in the category of Iron and Steel, stated that water represented 57% of utility bills, excluding telephones. Figure 9.5 provides a comparison of the relative annual proportions of site budgets for water and electricity.


MAJOR CUSTOMER SAMPLE
WATER & ELECTRICITY AS A PERCENTAGE OF SITE UTILTIY COSTS
FIG 9.5
ELECTRICITY
WATER
FREQUENCY
35
30
25
20
15
10
5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 100
MID-POINT % SITE BILL

9.3 MAJOR TRADE SAMPLE : EXAMINATION OF CONSERVATION

The approach to determine customer sensitivity to price increase provided an opportunity to estimate conservation potential. In practice a marked difference between theoretical answers and actual response was noted. At the percentage levels tested, virtually no demand modifications had been experienced.

Thus in the twelve months following an increase in water bills of 10%, above inflation, individual site consumption was not measurably influenced. It is however considered highly probable that deliberate conservation, on a large scale, would take many months and considerable organisation to achieve worthwile results.

Respondents were asked sets of questions to determine measures that they had already implemented, to conserve water, and secondly the potential for further conservation.

9.3.1 IMPLEMENTED MEASURES

The subject of conservation measures, which had already been implemented, was approached indirectly following the customers assessment of value for money. The approach worked particularly well for customers who declared that bills were too high. A selection of four specific on-site conservation measures was offered for discussion. These were:-

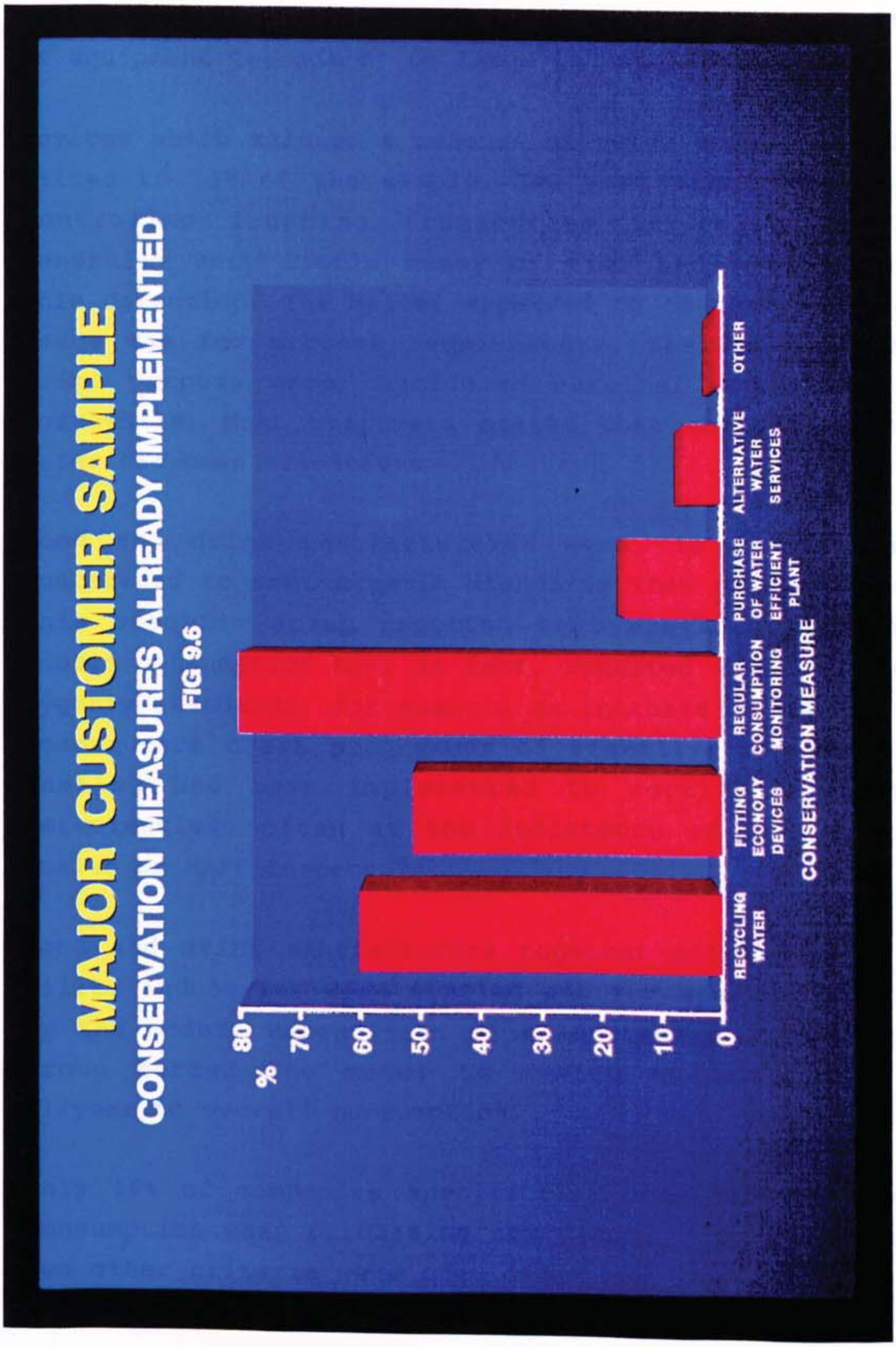
1. RECYCLING WATER.
2. USE OF WATER ECONOMY DEVICES (RETROFITTED).
3. REGULAR MONITORING.
4. USE AND PURCHASE OF WATER EFFICIENT PLANT.

Two other options were also made available. The first was a catchall labelled "other". Only one customer made use of this option, in reference to the use of South Staffordshire Water to locate hidden leakage. The second option related to the availability of alternative sources of water. Most commonly available were on-site wells or boreholes. Five customers had such facilities but most regarded the costs of winning and treating alternative resources as uneconomic. The availabilty of alternative water resources proved significant, in the model, explaining variations in consumption. The model, in fact, assigned a value of 40 Ml per year to such a resource. Thus sites with alternative facilities would require an average of 40 Ml/year less from South Staffordshire Water PLC.

Eighteen sites had employed consultants to undertake energy reviews. In general, corresponding to the proportion of utility bills, consultants had made relatively few suggestions to conserve water unless it, for example, absorbed energy for heating. Most companies recognised that savings were possible.

Figure 9.6 demonstrates that the most popular method of conserving water was the use of regular monitoring. This was undertaken by 72 (80%) of the sample who physically read water meters on a regular basis. The most diligent frequency being daily whilst the majority were split between weekly and monthly.

Recycling of water was undertaken by 60% of the sample. The most frequent justification being to conserve heat and chemical costs followed by limiting charges for effluent disposal. An early version of the explanatory model assigned the value of 75 Ml/year to the provision of reycling plant. The value, however, was assigned a positive value apparantely indicating incresed consumption on a given site fitted with recycling plant.


MAJOR CUSTOMER SAMPLE
CONSERVATION MEASURES ALREADY IMPLEMENTED
FIG 9.6
%
80
70
60
50
40
30
20
10
0
RECYCLING WATER
FITTING ECONOMY DEVICES
REGULAR CONSUMPTION MONITORING
PURCHASE OF WATER EFFICIENT PLANT
ALTERNATIVE WATER SERVICES
OTHER
CONSERVATION MEASURE

The models evidence was therefore contradictory to the very term "recycling". Investigation revealed that the propensity was for recycling to be accepted practice for larger customers. Particularly sites consuming in excess of 50 Ml/year. It was therefore interpreted that the assignment of 75 Ml/year to such plant was a recognition of equipment "standard" to large industrial consumers.

Devices which allowed a measure of water economy had been fitted to 51% of the sample. The most often used device controlled flushing frequencies in toilet blocks. Generally very little money or time had been spent in this direction. The belief appeared to be that bulk water usage was for process requirements. Savings outside of prime purpose were considered marginal and almost not worthwhile. Most customers stated that obvious waste of water had been eliminated.

Food and drink manufactureres were, in general, more concerened to meet hygenie standards than conserve water. This specific group reported that previous efforts to reduce consumption had, in fact, resulted in a decline of hygenie standards, for example an increase of odour. As a consequence crash programmes of steralization and plant washing had been implemented to rectify potential defeciencies, often at the insistence of Environmental Health or MAFF Inspectors.

Food and drink manufacturers together with chemical and allied industries were singled out for special treatment by the model. Recognition of belonging to this specific group forced the model to assign an additional 106 Ml/year to overall consumption.

Only 16% of companies specifically considered the water consumption when purchasing new plant. In this respect two other criteria were considered more important by most

MID-POINT CONSUMPTION Ml/YEAR	RECYCLE Yes/No	ECONOMY DEVICES Yes/No	MONITOR Yes/No	WATER EFFICIENT PLANT Yes/No
25	21 22	22 21	30 13	5 38
50	16 9	10 15	21 4	2 23
150	10 2	7 5	12 0	3 9
275	5 0	3 2	5 0	2 3
425	1 2	2 1	3 0	1 2
600	1 0	1 0	1 0	1 0
ALL	54 35	45 44	72 17	14 75

customers. These were the absolute cost of new plant, best able to perform the required task, and its conventional energy requirements such as gas or electricity consumption. The 16% who considered water as a factor were primarily concerned with the associated energy costs of heating, pumping and chemicals.

The cross tabulation shown as Table 9.1 demonstrates that water recycling and consideration of economy devices remain as options for 35 and 44 of customers respectively across all sizes except the single largest.

9.3.2 ASSESSMENT OF POTENTIAL CONSERVATION

Having assessed conservation measures already implemented the interview was directed towards an assessment of unrealized water conservation potential.

To ease the shift towards the subjective approach, necessary for contingent valuation, questions were linked to physical rather than fiscal criteria. Two directions were taken to determine response. The first dealt with potential on-site water volumes which could be saved and the second related to supply pressures.

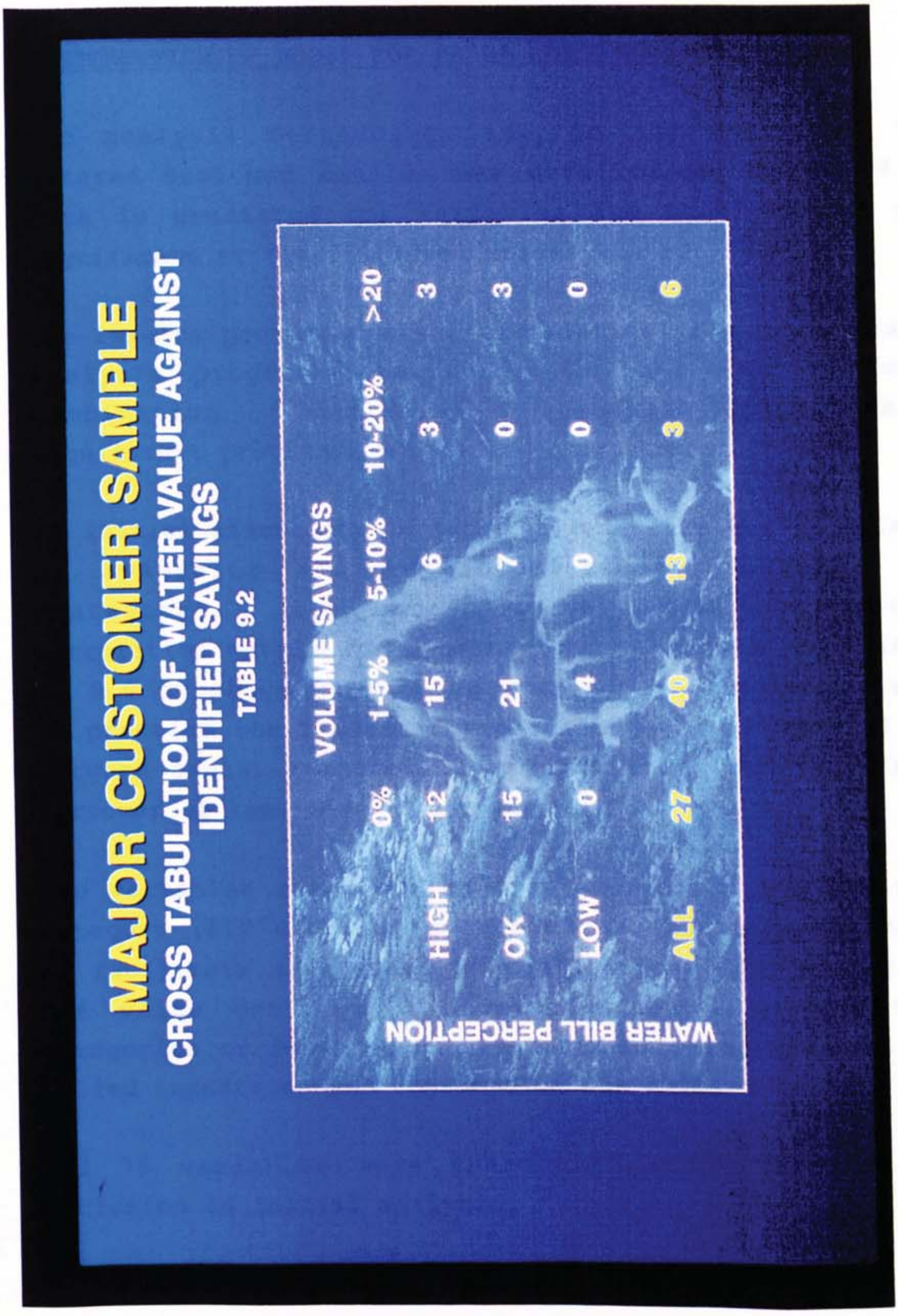
To remind respondents of customers past ability to operate with reduced water the occurrence of historic resource shortage was discussed. Customers were polled to determine if they had any recollection of the most recent national events which affected themselves, in 1976 and 1982. 23 stated that they could remember appeals for voluntary shortage but only 8 could remember the underlying reasons. Of this number only 2 customers were ably to correctly recollect both the reason and year (+/-1).

Customers were then asked what levels of conservation were realistically available on-site, whilst continuing to ensure full production and welfare provision. In response 30% of customers vehemently stated that there was absolutely no potential for water conservation on site. In addition the majority of this group declared their intention to refuse to co-operate with short term voluntary appeals for conservation.

Conversely 45% of customers recognised that at least 1-5% permanent savings could be achieved with minimal effort or cost. An additional 18% thought savings of up to 20% could be achieved with reasonable planning and expenditure on new plant. Finally 7% of the sample indicated knowledge of substantial misuse which if addressed could yield permanent savings in excess of 20%.

The potential savings identified by respondents were cross tabulated with perceptions of value for money. Results are shown as Table 9.2. Reference to the table proves instructive. Of the 39 respondents who stated that water service costs were high (poor value for money) twelve identified potential on-site savings in excess of 5% . Three of these in fact identify savings in excess of 20%. This suggests that the respondents do not have very strong concerns about water cost and value for money.

The interview proceeded to examine potential conservation through whole site pressure control. Respondents were asked if the site had been subject to unsatisfactory pressures. In reply 68% stated that pressures remained above adequate. 32% however declared that they could remember inadequate pressure. In view of the importance of these customers, the geographic spread, and the duplication of supplies this statement created some concern.


MAJOR CUSTOMER SAMPLE
CROSS TABULATION OF WATER VALUE AGAINST IDENTIFIED SAVINGS
TABLE 9.2
VOLUME SAVINGS
0% 1-5% 5-10% 10-20% >20
HIGH 12 15 6 3 3
OK 15 21 7 0 3
LOW 0 4 0 0 0
ALL 27 40 13 3 6
WATER BILL PERCEPTION

With limited further investigation and probing, only two customers indicated a long standing concern with the companies supply pressures. Both were subsequently investigated and addressed.

9.4 CONSTRUCTION OF MODEL FOR MAJOR CUSTOMERS

The analysis methodology adopted and developed for metered customer samples was detailed in Section 4.1. Data is presented for variables and models which are significant at the 95% level unless stated.

The results presented are a distilation of a considerable analysis programme searching for the most suitable combination of variables to generate statistically significant predicure models.

An initial assessment of multicollinearity was undertaken by assessing all variables except "output" and "category". The variables were compiled into a correlation matrix for examination. Variables correlated at 0.6 or above were to be examined in greater detail. In practice the highest correlation was a value of 0.569 between annual turnover, less than £10m, and decreasing turnover of less than 5% per annum.

The variables representing "years-on-site" and customer category (SIC Code) were recoded as indicator variables to facilitate analysis. No correlations approaching the 0.6 value occurred. However a trend between user categories of food and drinks manufacturers, chemical and allied industries and consumption was evident.

All 75 variables were therefore carried forward for inclusion in initial analysis.

The analysis methodology adopted, as described in Chapter 4, employed regression analysis based upon the case studies (Sec. 2.7) to determine the significance of combinations of variables. Data was analysed in logical groups, such as site usage or conservation measures. The dependant variable was selected as annual consumption. For the major customer sample the units were Ml/year to best represent the large volumes involved.

At each stage of regression analysis, the "Variance Inflation Factors" (VIF) were computed to further measure multicollinearity (Sec. 2.7.2). Values in excess of 1.5 were excluded, values between 1.2 and 1.5 were considered in greater detail before deciding upon inclusion and values less than 1.2 were carried forward for re-assesment with other variables removed.

The 24 cases occurring within category A, Metal Manufacturing were initially separated to search for relationships without distraction of multiple categories.

As the analysis progressed, the number of variables was steadily reduced to 24. Criteria for retention were high "t-ratio's", low "p" values high "F" values and optimum R-squared (Sec. 4.1). Consideration was also given to variables that subjectively appeared to represent relationships with consumption but did not feature as significant in the model. The second stage of analysis progressed with the following variables:-

1. Classification (SIC coding).
2. Output.
3. Use of water for cooling.
4. Use of water for washing (hygiene).
5. Use of water for process.
6. Environmental usage of water.
7. Other miscellaneous uses of water.
8. Seasonal fluctuations in consumption.
9. Continuous (7day/24 hr) working.

10. Shift work (not continuous).
11. Other working patterns.
12. Recycle water for re-usage.
13. Fitted economy devices.
14. Regularly monitor water consumption.
15. Purchase of water efficient plant.
16. Alternative water sources in use.
17. Turnover below £0.5 M/annum.
18. Turnover £0.5 to £1 M/annum.
19. Turnover £1 to £5 M/annum.
20. Turnover £5 to £10 M/annum.
21. Turnover greater than £10 M/annum.
22. People on-site.
23. Site size in ha.
24. Year on site.

The final model assigned significance to just four variables, with a constant term, or 3 values if re-computed without an intercept. The strength of the latter model was considerably greater and is thus presented as the preferred combination of predictor variables:-

$$Q_{mt} = 125(I_{mc}) + 0.058(I_{m5}) + 2.85(I_{m6}) \ldots (1)$$

[F=57.79, p=0.000]

where:-

Q_{mt} = Annual trade consumption, for major customers units Ml/year

I_{mc} = Value 0 for all customers except Value 1 for either Food and Drink manufacturers or Chemical and Allied Industries

I_{m5} = People on site

I_{m6} = Site Area in hectares

If a constant term is retained the model/becomes:-

$$Q_{mt}=29+106*(I_{mc})-39.9*(I_{mS})+0.0303*(I_{m5})+2.91*(I_{m6})\ldots 2$$

[R-sq=61%, F=23.37, p=0.000]

Where the additional term:- I_{mS} represents the availability and usage of alternative water supplies.

The model was subsequently tested against independent information from 85 customers held in the 93/94 billing file. Summary data is included as Appendix E. Surveys were undertaken to establish the required data for people on site and site area. Full response was only obtained from 32 customers.

Analysis of the data for these 32 cases resulted in the following:

Phase II Major Customer Sample	Actual Mean Consumption Ml/year	Model (2) Mean Consumption Ml/year
32 cases	37	50

Given the small sample size the correspondence is considered reasonable Analysis of the data indicated a number of changes affecting the original concept of this model: the Major Customer population had been expanded from 200 accounts, company-wide, to approximately 1500. Consequently the lower consumption threshold had been reduced below the 1 Ml/yr threshold. In addition customers, and in particular schools, presented information which included total people on site i.e. employees plus pupils. The models were calibrated for employees only.

As a consequence cases of consumption below 1 Ml/year and those were people on site included pupils were removed. The 32 cases tested excluded these items.

9.5 DISCUSSION OF MAJOR TRADE MODEL

The eventual simplicity of the model was unexpected. The majority of data collected did not figure as significant within the overall predictive relationship.

Of particular surprise variables such as patterns of working, conservation measures implemented and scale of production output were not shown to be statistically consistent with water consumption. This statement not only applied to this entire sample but also to the largest subgroup comprising the specific category of "metal manufactures". The absence of such anticipated elements, in the model, is assumed to be due to the confusion inherent in one variable attempting to represent a multiplicity of determinates, i.e. shift working/seasonal variables already catered for in "people on site".

The fact that the sample represents a very specific group of customers, at South Staffordshire Water, and the high probability ascribed to the model suggests that it can be applied with reasonable confidence to other cases with similar characteristics. It must be remembered that the model is for LARGE INDUSTRIAL CUSTOMERS ONLY.

9.6 ALL METERED CUSTOMER SAMPLE : ANALYSIS AND CONSTRUCTION OF MODEL

The second metered sample was randomly generated from the database of all metered accounts held by South Staffordshire Water at 1988. This approach was in direct contrast to the targetting of a specific group for the major sample. Examination of the data revealed that cases covered 10 of the 21 SIC categories detailed in table 8.2.

Figure 9.7 provides an illustration of the sample, split by category. 66% of the sample was covered by the three categories representing domestic and commercial meter options. In total these represent 64.1% of the population and therefore confirm reasonable correspondence between sample and population.

Groups Y and X represent commercial properties who have either elected (X) or been obliged to have water meters fitted (Y). Both groups are predominatly represented by small commercial premesis or high street shops. Water usage is typically for domestic requirements such as food preperation, ie in kitchens, or toilet flushing.

As an indicator, of levels of consumption, the model for the complete sample, relative to customer category, only is :-

$$Q = 792+1486(I_2)+2448(I_4)+6541(I_7)+1196(I_{12}) -230(I_{13})+58(I_{16})-601(I_{19})-346(I_{20}) \ldots (3).$$

(R-sq=35%)

where :-

Q= Annual consumption in m3.

I_2= Educational Establishment

I_4=Commercial/public service establishment

I_7=Sports and Recreational Establishment.

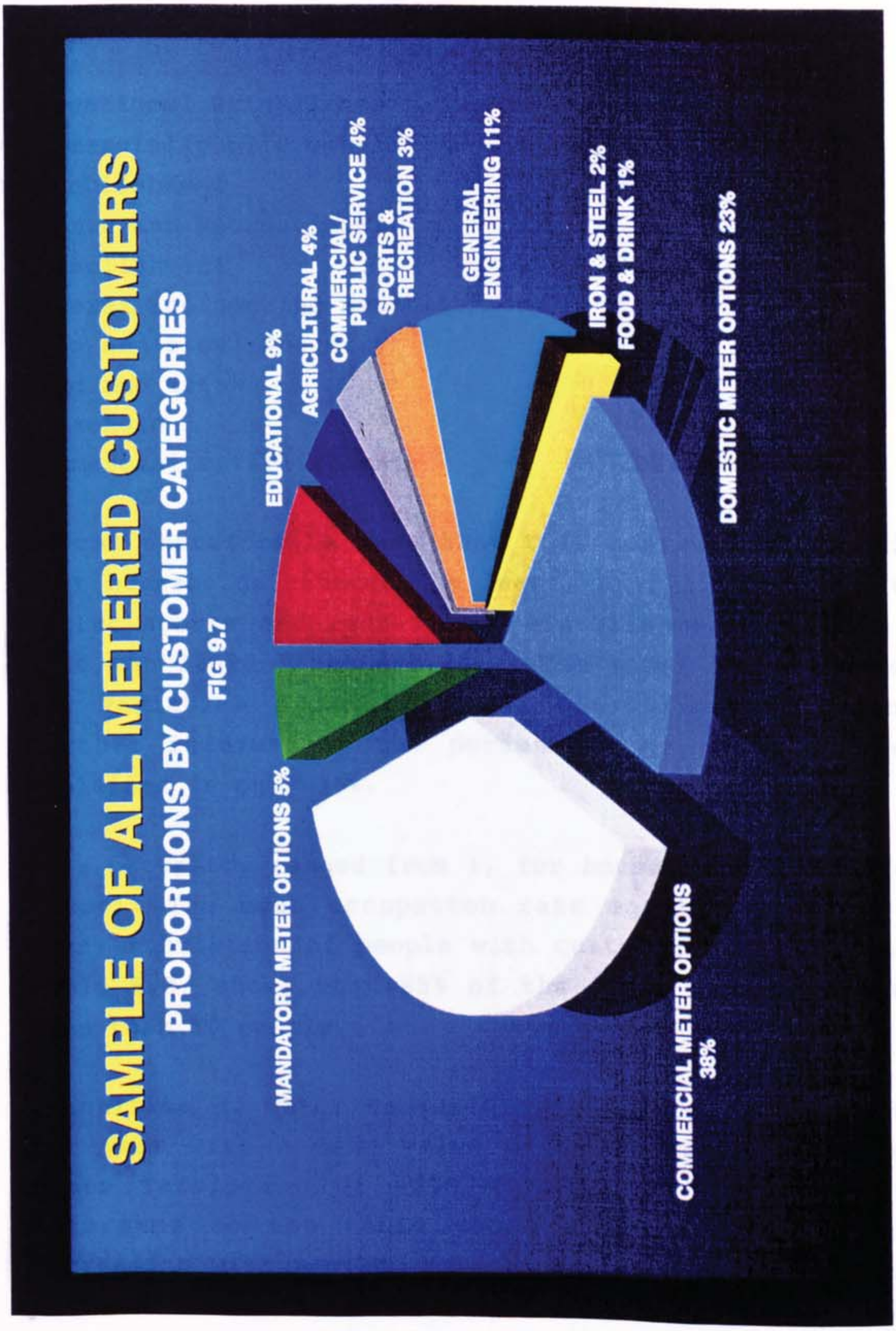
I_{12}=General Engineering Establishment.

I_{13}=Iron and steel industry

I_{16}=Food and drink

I_{19}=Household

I_{20}=Commercial establishment.


SAMPLE OF ALL METERED CUSTOMERS
PROPORTIONS BY CUSTOMER CATEGORIES
FIG 9.7
MANDATORY METER OPTIONS 5%
EDUCATIONAL 9%
AGRICULTURAL 4%
COMMERCIAL/
PUBLIC SERVICE 4%
SPORTS &
RECREATION 3%
GENERAL
ENGINEERING 11%
IRON & STEEL 2%
FOOD & DRINK 1%
DOMESTIC METER OPTIONS 23%
COMMERCIAL METER OPTIONS
38%

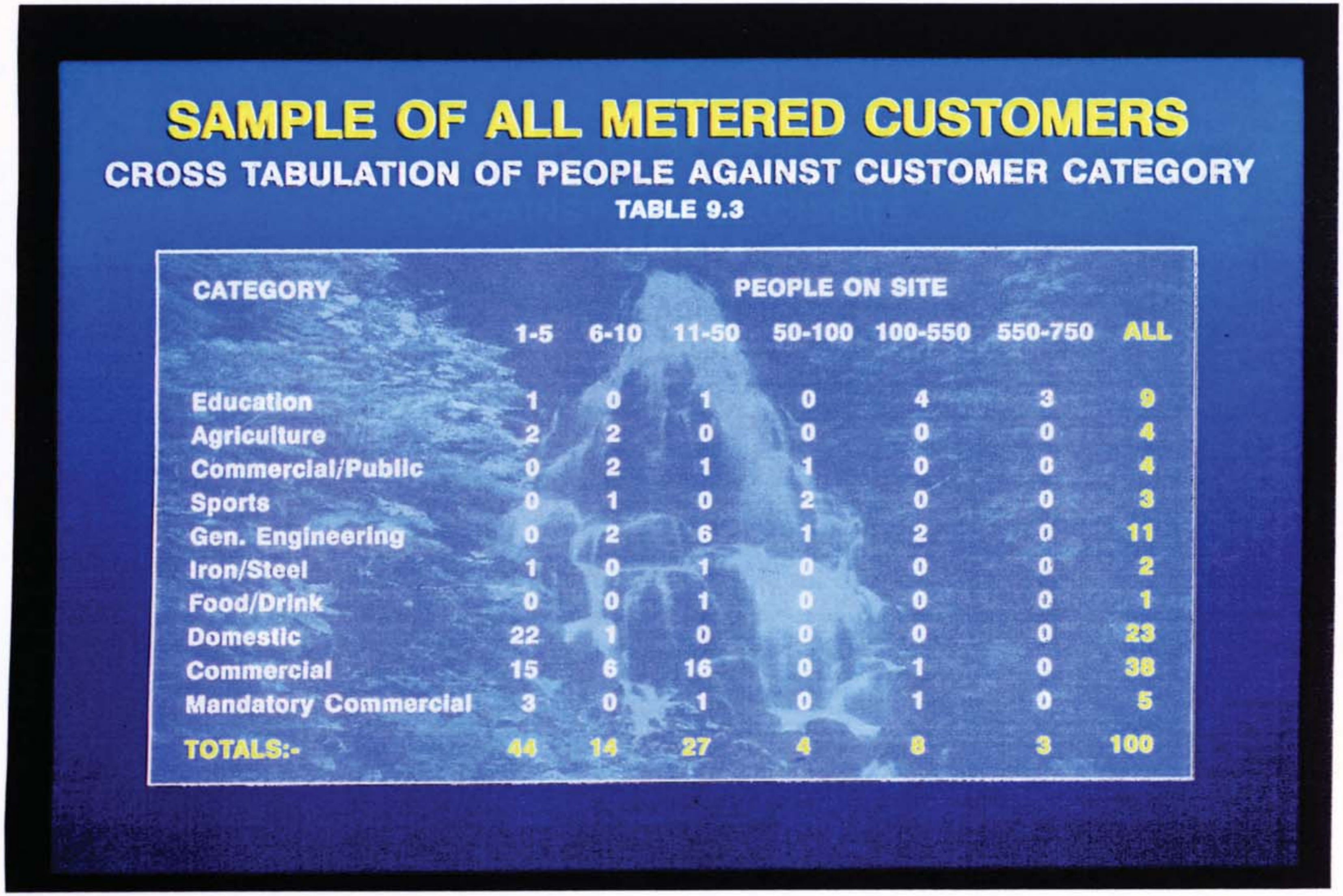
The model is calibrated in cubic metres of water consumed per year. Thus equivalent daily consumption allowances for each category equate to:-

CATEGORY	DAILY CONSUMPTION l/prop/day
Educational Establishment	6241
Commercial/public service establishment	8876
Sports and Recreational Establishment	20090
General Engineering Establishment	5446
Iron and steel industry	1539
Food and drink	2010
Household	523
Commercial establishment	1221

It can therefore be seen that this coarse model predicts that households consume the least, at 523 l/property/day, whilst sports and recretional establishments consume the most, at 20090 l/property/day. The model however ignores all variables except customer classification. With no further information the percentage of being correctly explained is only 35%.

Site occupancy ranged from 1, for households to 750 for a school. The mean occupation rate equated to 53.1. The cross tabulation of people with customer classifications, table 9.3, shows that 85% of the sites were occupied by less than 50 people.

Quantities of water consumed ranged from 10 to 11000 m3 per year with a mean value of 1099. Table 9.4 shows a Cross Tabulation of site consumption with occupancy. Reference to the table shows a trend of consumption increasing with people. Exceptions, in general, relate to customers that would, generally, be described as industrial, ie manufacturing rather than commercial premesis. This indicates that the number of people-on site becomes less of a predictor as we move from domestic to industrial premesis.

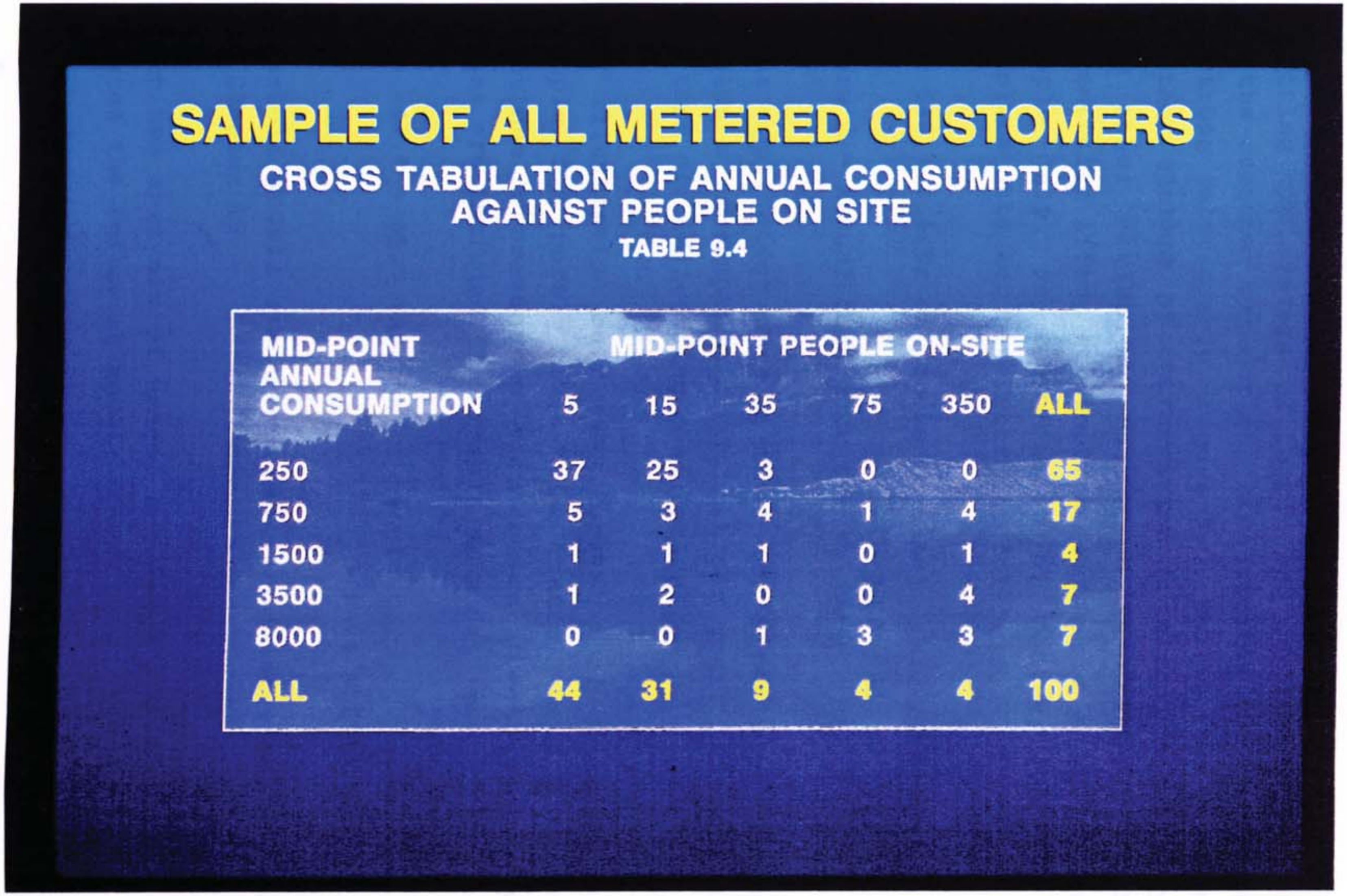


SAMPLE OF ALL METERED CUSTOMERS

CROSS TABULATION OF PEOPLE AGAINST CUSTOMER CATEGORY

TABLE 9.3

CATEGORY	PEOPLE ON SITE						
	1-5	6-10	11-50	50-100	100-550	550-750	ALL
Education	1	0	1	0	4	3	9
Agriculture	2	2	0	0	0	0	4
Commercial/Public	0	2	1	1	0	0	4
Sports	0	1	0	2	0	0	3
Gen. Engineering	0	2	6	1	2	0	11
Iron/Steel	1	0	1	0	0	0	2
Food/Drink	0	0	1	0	0	0	1
Domestic	22	1	0	0	0	0	23
Commercial	15	6	16	0	1	0	38
Mandatory Commercial	3	0	1	0	1	0	5
TOTALS:-	44	14	27	4	8	3	100



SAMPLE OF ALL METERED CUSTOMERS

CROSS TABULATION OF ANNUAL CONSUMPTION AGAINST PEOPLE ON SITE

TABLE 9.4

MID-POINT ANNUAL CONSUMPTION	MID-POINT PEOPLE ON-SITE 5	15	35	75	350	ALL
250	37	25	3	0	0	65
750	5	3	4	1	4	17
1500	1	1	1	0	1	4
3500	1	2	0	0	4	7
8000	0	0	1	3	3	7
ALL	44	31	9	4	4	100

Table 9.5 provides an assessment of people, site area and consumption for each of the 10 customer categories included in the sample. The table also provides a summary of water utilization: Split into cooling, bulk storage, process and other. Each case also included domestic usage which has therefore been excluded from analysis.

Plotting the average of people and consumption for each of the customer categories demonstrates the existence of a strong relationship, Figure 9.8. Whilst this provides a further element of conformation it also ignores many of the other variables, discussed in chapter 3, which potentially affect consumption. Further a model fitted to people only, as a predictor of consumption for the complete data set generates the following:-

Q = 643 + 8.4(Nr of people on-site).........(4).

[R-sq =26%]

where Q = Annual consumption in m3/year.

Thus application of the model for sites with no people yields a consumption of 643 m3 per year. Clearly other factors are influencing consumption.

For illustration only the regression of consumption and people for purely household customers in the group, provides a reasonable association given that only 23 cases are included. The resultant model is:-

Q = -44.8 + 85.7 (Number of people)..........(5).

[R-sq = 69%]

Houshold models are developed, and discussed in detail, in Chapter 10.

Combined analysis of usage, occupancy and site area generates the following model:-

$Q=376-202(I_1)+6858(I_2)+2555(I_3)+149(I_4)+3.65(I_5)+1464(I_6)$...6

[R-sq=71.5%]

SAMPLE OF ALL METERED CUSTOMERS

PRESENTATION OF USAGE, PEOPLE, AREA AND CONSUMPTION DATA BY CUSTOMER CATEGORY

TABLE 9.5

	DESCRIPTION	OBSE RVAT IONS	COOL	BULK STOR AGE	PROC ESS	OTHER	PEOPLE ON SITE MAX	MIN	AVG	STD
2	Education	9	0	1	0	2	750	4	342.0	298.0
3	Agricultural	4	0	0	0	4	6	2	3.0	2.0
4	Commerce Public Ser	4	0	2	0	1	100	10	53.3	40.8
7	Sports & Rec.	3	0	2	0	1	100	8	69.3	53.1
12	General Engineering	11	6	1	3	4	550	7	91.2	159.0
13	Iron & Steel	2	2	2	0	2	33	3	18.0	21.2
16	Food & Drink	1	0	0	1	0	17	17	17.0	*
19	Domestic Options	23	0	0	0	0	6	1	2.69	1.608
20	Commercial Options	38	2	0	1	6	150	1	15.1	24.7
21	Mandatory Commercial	5	0	0	0	2	150	3	38.4	63.4

Sheet 1

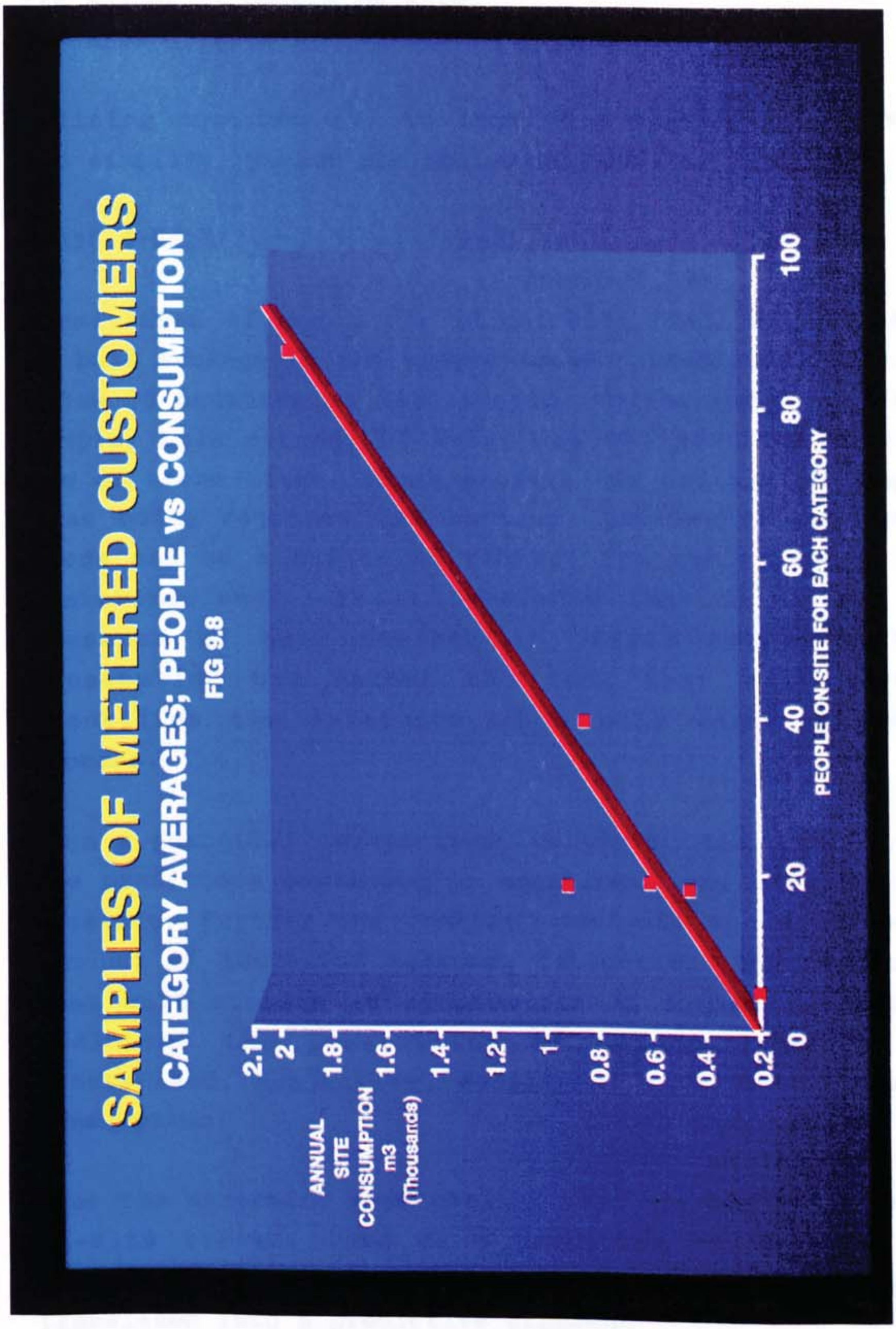
SAMPLE OF ALL METERED CUSTOMERS

PRESENTATION OF USAGE, PEOPLE, AREA AND CONSUMPTION DATA BY CUSTOMER CATEGORY

TABLE 9.5

	DESCRIPTION	SITE AREA ha				CONSUMPTION m3/YR			
		MAX	MIN	AVG	STD	MAX	MIN	AVG	STD
2	Education	3.4	0.55	2.04	1.05	9000	600	2278	2666
3	Agricultural	0.9	0.44	0.613	0.25	3000	430	1362	1169
4	Commerce Public Ser	7.71	0.49	2.93	4.14	11000	160	3240	5186
7	Sports & Rec.	1.5	0.06	0.83	0.72	10000	2000	7333	4619
12	General Engineering	4.21	0.029	0.76	1.53	9000	100	1988	3006
13	Iron & Steel	0.01	0.01	0.01	*	1100	25	563	760
16	Food & Drink	*	*	*	*	850	850	850	*
19	Domestic Options	0.55	0.002	0.11	0.15	600	10	186.2	165.8
20	Commercial Options	0.93	0.002	0.07	0.17	6000	20	439	1123
21	Mandatory Commercial	0.16	0.048	0.01	0.08	2100	26	800	854

Sheet 2


SAMPLES OF METERED CUSTOMERS
CATEGORY AVERAGES; PEOPLE vs CONSUMPTION
FIG 9.8
ANNUAL SITE CONSUMPTION m3 (Thousands)
2.1
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
40
60
80
100
PEOPLE ON-SITE FOR EACH CATEGORY

where: Q= Annual site consumption in m3.
and I_1= Cooling usage yes=1, 0=no
I_2= Prescence of bulk storage yes=1, 0=no.
I_3= Water used for process yes=1, 0=no.
I_4= Allowance for other usage yes=1, 0=n0.
I_5= Number of people on site.
I_6= Area of site hectares.

Refining equation (6) to improve prediction confidence and simplify, yields the following model:-

$$Q=396.8+6823(I_2)+3.5(I_5)+2398(I_3)+173(I_6)..(7)$$
[R-sq=71.43%]

Examination of model (7) illustrates that the prescence of bulk storage is the single largest predictor for sites below 39 hectares or 1950 people. Unlike the Major Trade Sample, bulk storage of water was not provided at every one of these sites. (Bulk storage was defined in Chapter 3 as being required to satisfy process or production needs and as a buffer to protect the public mains from contamination). It is concluded that it is not the presence of bulk storage in itself that generates consumption but rather the fact that bulk storage identifies the existence of a bulk water consuming process.

From a practical perspective, veryfying the occurence of the predictors expressed in equation 4 may not always be possible. Further the combined analysis so far takes no account of identifed customer categories. The conclusion that bulk storage is symptomatic of higher consumption indicates the possibility of determining a more generalised, subjective, assessment in order to predict consumption.

Thus the statement made earlier that the number of people on-site becomes less of a predictor as we move from domestic to industrial premesis can, perhaps, be translated into a predictive argument.

Reference to Table 9.5 illustrates customer categories exhibiting usage of water for purposes other than domestic.

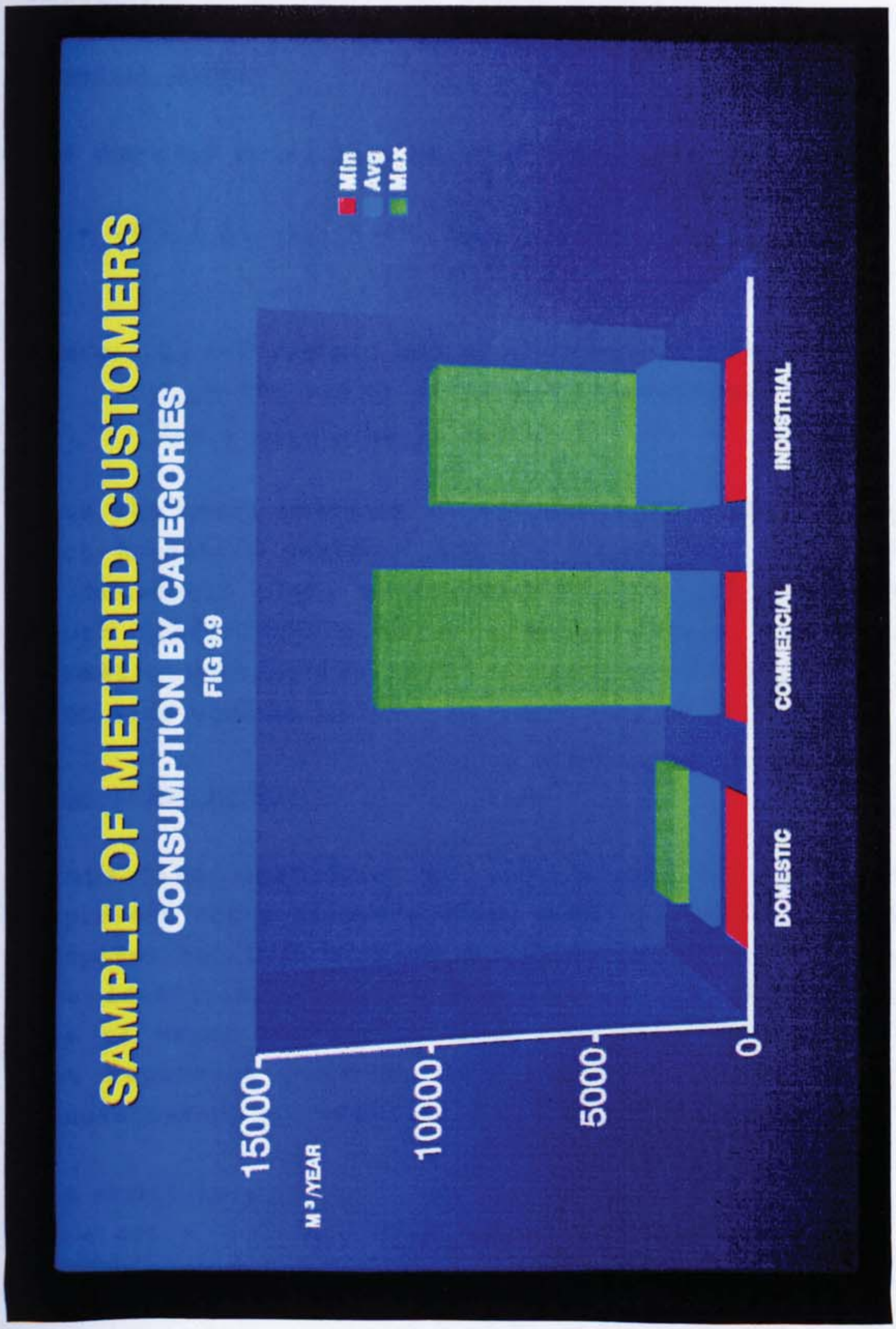
Stepping through the data, stripping out cases which are identified by successive, discrete, elements of utilization generates a series of models ultimately excluding usage other than for domestic purposes. This includes those commercial premesis were it was identified, from the survey, that water was used only for domestic purposes. For example high street shops and banks are included but leisure complexes, small manufacturing (commercial) properties, farms and industrial premesis using water for process or cooling are excluded.

The resultant models, starting with all classes of water utilization moving to only domestic are:-

step	excludes	R-sq
0	nothing	71.4.from eqn (6)
1	bulk storage	67%
2	process	23%
3	other	47%
4	cooling	51%

The analysis and models so far suggest that identification of a general predictor to represent consumption in addition to people on-site may also allow improved confidence.

Thus the data was reanalysed and eventually split into three broad categories rather than the 21 shown in table 8.2 household. Figure 9.9 illustrates minimum, mean and average site consumptions for each category. The definitions of category identifiers were developed by improving predictive confidence using the maximum R-sq technique. Thus the model identified which aspects of water utilization to include or ignore in order to assess the simplified cateroganization. The three separate models that resulted were labelled as :- domestic, commercial and industrial for convenience.


SAMPLE OF METERED CUSTOMERS
CONSUMPTION BY CATEGORIES
FIG 9.9
Min
Avg
Max
M³/YEAR
15000
10000
5000
0
DOMESTIC
COMMERCIAL
INDUSTRIAL

A combined model was also developed, specifying category with indicator variables linked to a base of domestic calibration. However for practical use the dedicated models are favoured. The raw data for each of the three categories is presented as tables 9.6, 9.7 & 9.8.

Domestic Model:

The domestic model fits metered households only and is:-

$$Q_C = -9.6 + 51.9 I_{C2} + 471\ I_{C6} \ldots\ldots (8)$$

[R-sq=73.5%]

where:- Q_C = Household annual consumption in m3.
I_{C2}= The number of people in residence.
I_{C6} = Site area in hectares.

Thus the model provides an allowance of 51.9 m3/year for each household resident and 471 litres for each hectare of household plot. By coincidence the 1991/1992 quoted South Staffordshire Water average figure, allowed for domestic consumption, with no additional allowance for plot size equates to 65.7 m3/year.

Commercial Model:

Properties described as commercial for this model represent those premesis where water is used for domestic purposes but bulk storage or "other uses" beyond domestic are identified. Typical examples in the sample include use of water for agricultural purposes. This model does not represent premsis where water is used for either manufacturing processes or for cooling purposes.

The model is:-

$$Q_C = 466 + 6971(I_{C2}) + 3.37(I_{C5}) \ldots\ldots\ldots\ldots\ldots (9)$$

Q_C = Commercial site annual consumption in m3.

[R-sq=69.7%]

where :-

I_{C2} = Indicator variable for bulk storage provision ie yes=1 no=0.

I_{C5} = The number of people on site.

SAMPLE OF ALL METERED CUSTOMERS

DATA FOR DOMESTIC CATEGORY

TABLE 9.6

CODE		WATER USAGE		WATER USAGE				
REF	SIC CODE	COOLING	STORAGE	PROCESS	OTHER	Nr. PEOPLE	ANNUAL CON'S (M^3)	AREA SITE (ha)
7	19	0	0	0	0	5	400	0.065
23	19	0	0	0	0	4	256	0.090
26	19	0	0	0	1	4	550	0.370
36	19	0	0	0	0	2	100	0.112
38	19	0	0	0	1	1	75	0.043
41	19	0	0	0	0	1	25	0.040
45	19	0	0	0	0	2	100	0.034
48	19	0	0	0	1	3	600	0.450
51	19	0	0	0	1	4	180	0.115
53	19	0	0	0	1	1	84	0.036
54	19	0	0	0	0	1	70	0.030
57	19	0	0	0	0	4	120	0.045
58	19	0	0	0	1	2	60	0.032
72	19	0	0	0	1	2	71	0.004
74	19	0	0	0	0	4	65	0.060
77	19	0	0	0	0	1	66	0.050
86	19	0	0	0	1	2	187	0.060
88	19	0	0	0	0	2	83	0.013
96	19	0	0	0	0	1	10	0.002
98	19	0	0	0	0	2	170	0.032
76	19	0	0	0	0	6	350	0.553
89	19	0	0	0	1	4	310	*
49	19	0	0	0	0	3	350	0.250

SAMPLE OF ALL METERED CUSTOMERS

DATA FOR COMMERCIAL CATEGORY

TABLE 9.7

CODE		WATER USAGE		WATER USAGE		Nr.	ANNUAL	AREA
REF	SIC CODE	COOLING	STORAGE	PROCESS	OTHER	PEOPLE	CON'S (M^3)	SITE (ha)
1	20	0	0	0	0	10	25	0.003
4	4	0	0	0	1	73	1000	0.6
5	3	0	0	0	1	6	3000	0.9
8	20	0	0	0	0	50	6000	0.9373
9	7	0	1	0	0	100	16000	1.500
10	4	0	1	0	0	100	11000	0.4880
12	7	0	1	0	0	100	16000	0.630
14	12	0	0	0	0	50	330	0.1840
15	2	0	0	0	1	300	1000	0.552
17	21	0	0	0	0	150	2100	*
18	4	0	1	0	0	30	800	*
19	2	0	0	0	0	650	3000	3.020
21	20	0	0	0	0	20	200	0.225
22	20	0	0	0	0	25	250	0.0277
24	2	0	0	0	0	17	800	1.30
27	2	0	0	0	1	238	900	1.20
28	2	0	0	0	0	262	2000	1.898
29	2	0	0	0	0	750	2500	3.20
30	2	0	0	0	1	117	700	2.0
31	20	0	0	0	0	15	100	0.0126
32	20	0	0	0	0	5	55	0.0084
33	20	0	0	0	0	12	64	0.0048
34	20	0	0	0	0	17	105	0.0128
35	2	0	0	0	0	4	600	*
37	2	0	1	0	0	740	9000	3.40
40	20	0	0	0	0	5	34	0.01
42	20	0	0	0	0	20	115	0.012
43	20	0	0	0	0	5	30	0.018
44	20	0	0	0	0	3	34	0.009
46	13	0	0	0	0	3	25	0.0105
47	20	0	0	0	0	4	40	0.002
50	20	0	0	0	0	2	35	0.080
52	4	0	0	0	1	10	160	7.708
55	12	0	0	0	1	50	290	*
56	20	0	0	0	1	25	350	0.1564
59	20	0	0	0	1	10	106	*

Sheet 1

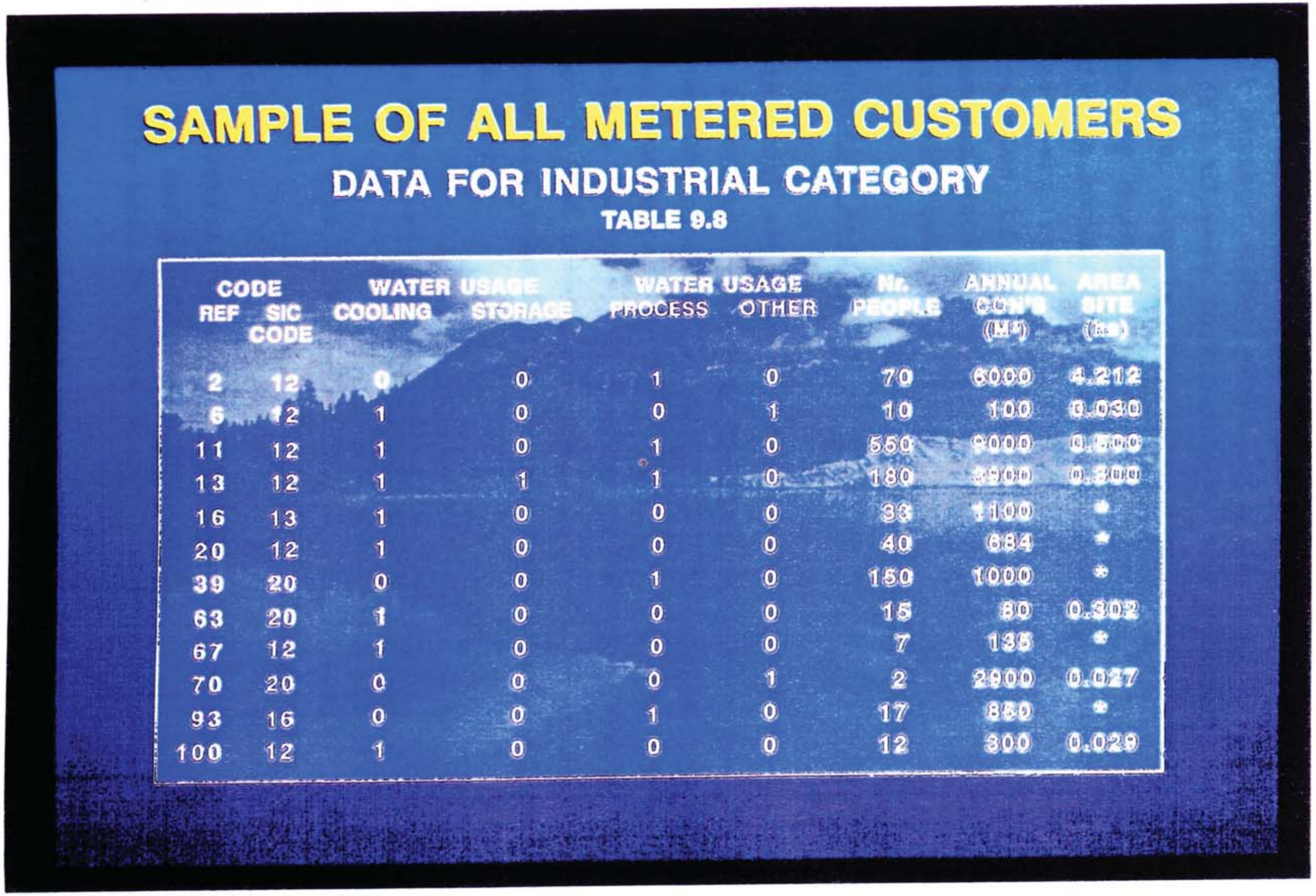
SAMPLE OF ALL METERED CUSTOMERS

DATA FOR COMMERCIAL CATEGORY

TABLE 9.7

CODE		WATER USAGE		WATER USAGE		Nr.	ANNUAL	AREA
REF	SIC CODE	COOLING	STORAGE	PROCESS	OTHER	PEOPLE	CON'S (M^3)	SITE (ha)
60	20	0	0	0	0	6	80	0.0072
61	20	0	0	0	0	8	236	0.0936
62	20	0	0	0	1	4	91	0.0049
63	20	0	0	0	0	13	80	0.3024
64	7	0	0	0	1	8	2000	0.06
65	20	0	0	0	0	1	160	0.019
66	20	0	0	0	0	11	90	0.0506
68	12	0	0	0	1	20	230	0.0837
69	20	0	0	0	1	14	150	0.3444
70	20	0	0	0	1	2	2900	0.0270
71	20	0	0	0	0	23	74	0.0042
73	21	0	0	0	0	30	1000	0.0486
75	20	0	0	0	1	4	98	0.0100
78	3	0	0	0	1	2	1400	*
79	20	0	0	0	0	11	68	0.0093
80	20	0	0	0	0	6	50	0.006
81	3	0	0	0	1	2	600	0.500
82	20	0	0	0	0	2	80	*
83	20	0	0	0	0	2	41	0.0027
84	20	0	0	0	0	4	44	0.0030
85	20	0	0	0	0	3	33	0.0097
87	21	0	0	0	1	5	34	0.1680
90	21	0	0	0	0	3	26	*
91	20	0	0	0	0	30	900	*
92	20	0	0	0	0	13	70	0.01
93	3	0	0	0	1	2	450	0.44
94	20	0	0	0	0	3	20	*
97	12	0	0	0	1	14	900	*
99	21	0	0	0	0	4	800	*

Sheet 2



SAMPLE OF ALL METERED CUSTOMERS

DATA FOR INDUSTRIAL CATEGORY

TABLE 9.8

CODE REF	SIC CODE	WATER USAGE COOLING	WATER USAGE STORAGE	WATER USAGE PROCESS	WATER USAGE OTHER	Nr. PEOPLE	ANNUAL CON'S (M³)	AREA SITE (ha)
2	12	0	0	1	0	70	6000	4.212
6	12	1	0	0	1	10	100	0.030
11	12	1	0	1	0	550	9000	0.500
13	12	1	1	1	0	180	3900	0.300
16	13	1	0	0	0	33	1100	*
20	12	1	0	0	0	40	684	*
39	20	0	0	1	0	150	1000	*
63	20	1	0	0	0	15	80	0.302
67	12	1	0	0	0	7	135	*
70	20	0	0	0	1	2	2900	0.027
93	16	0	0	1	0	17	850	*
100	12	1	0	0	0	12	300	0.029

It can therefore be seen that whilst the model for commercial consumption retains the term for people, it excludes a factor relating to site size. Examination of the data supports this solution in that some quite small premesis consume relatively large quantaties of water and vice-versa. The second term simulates the existence of bulk storage tanks. Where these do exist a notional value of 6971 m3/year is built into the equation. In practice the model clearly identifies that traditional commercial property consumption is strongly related to people. In addition moving towards more industrialised sites with a consequent step, in consumption is recognised by the provision of bulk water storage. In the model such premesis included leisure complexes, schools, colleges and health centres.

Industrial Model:

This model represents water usage for customers described as Industrial. Identifying characteristics are the use of water for process, ie water as a principle constituent of the manufacturing operation. Or the use of water for cooling purposes including industrial cleansing. Bulk storage and other uses are likely to be in existence but these are represented by other more dominant factors in the model.

The model is:-

$$Q_i = 689 + 14.3(I_5) + 1009(I_6) \text{..........} (10)$$

[R-sq=90%]

where:-

Q_i= Industrial site annual consumption in m3.

I_5= The number of people on-site.

I_6= Site area in hectares.

Thus it can be seen that for premesis identified as being industrial, dominant predictive factors are people and site area. Allowances are 14.3 m3/person/year on-site and 1009 m3/hectare of site area.

9.7 DISCUSSION OF ALL METERED CUSTOMER MODELS

All of the models include reference to occupation levels. For households and industrial customers the second variable is size of the site. This is taken to represent two complete, but differing, variable subsets. It is likely that for households the subset represents, for example, appliance ownership, affluence and garden size ie those variables identified for detailed examination in the much larger un-metered household sample.

For industrial customers the site size probably represents the scale of the business. Even when water is being used in a very local area, of a given plant, handling, for example, of bulk products to either service the operation or as finished products requires space or more specifically area.

Commercial premesis offered a variety of businesses interests ranging from a shop of 27 m^2 to large sites for sports and recreation. This later description particularly included schools with several acres of little used land. What became apparent, through the model, however was the representation of specific consumption to the tell-tale of bulk storage provision. Commercial customers are defined as not using water for cooling or process therefore the storage identifies other bulk uses.

In practice the three equations 8, 9 and 10 represent simplified but reasonable predictors of site consumption. In a limited number of subsequent checks assessment of category, ie domestic, commercial or industrial proved a very practical proposition. Slightly more difficult was the assesment of people, site area and provision of bulk storage. Contact with individual companies readily produced the information and enabled the models to be applied. In many cases these paramaters were assessed subjectively whilst maintaining reasonable results when compared to actual consumption records. Thus the models proved reasonably robust but demonstrated the virtue of simplicity.

The models were subsequently tested using data from an additional sample of 181 metered customers of all classes. A survey was conducted, by post, to determine site area and numbers of employees on site. After much cajoling 93 complete cases were obtained. The data is summarised as Appendix F.

Of the 93 cases 5 were household, 86 were commercial and 2 industrial. application of 8, 9 and 10 to the phase 2 sample resulted in the following:-

Phase II/All Metered Sample Customer Split	Actual Mean Consumption M3/yr	Model Mean Consumption M3/yr
5 domestic (Model 8)	102	107
86 commercial (Model 9)	557	615
2 industrial (model 10)	506	1105

The model results for domestic and commercial properties are acceptably close to the actual recorded consumption the discrepancy between predicted and actual for the industrial samples is incorrect by a factor of 100%. The sample was, however, only for 2 properties. this model requires further testing to check its performance.

9.8 ALL METERED CUSTOMER SAMPLE CONSERVATION ASPECTS

Having developed a model, using three broad classification of domestic, commercial and industrial, the remaining data can be examined with respect to conservation in a similarly structured manner.

Three groups of questions were presented to the interviewee. These were designed to:-

1. Determine knowledge and perception of water bill value.
2. Assess measures already implemented by customers to conserve water.
3. Apply the contingent valuation methodology to determine potential for conservation.

9.8.1 PERCEPTION OF BILL VALUE FOR ALL METERED CUSTOMER SAMPLE

Each of the 100 customers were asked to state current levels of water bill charges. Answers were compared to actual costs to determine accuracy of knowlege. If within 100% of actual value the response was marked as a YES. A secondary question was then asked to determine customer perceptions of value for money.

Across all three categories response followed a similar pattern:-

KNOWLEDGE OF BILL VALUE

	KNOW BILL VALUE		REGARD BILL AS		
	YES	NO	HIGH	OK	LOW
INDUSTRIAL	7	4	5	7	0
COMMERCIAL	30	35	21	43	1
DOMESTIC	13	10	4	19	0

A significant number of customers from all categories regarded the bill as acceptable. Figure 9.10 provides a detailed comparison of bill acceptance linked to verified accuracy. Thus it can be seen that a majority of customers thought water bills were acceptable and were commenting from a position of authority by virtue of knowing their personnel level of charge within 25%.

9.8.2 CONSERVATION MEASURES PRACTISED

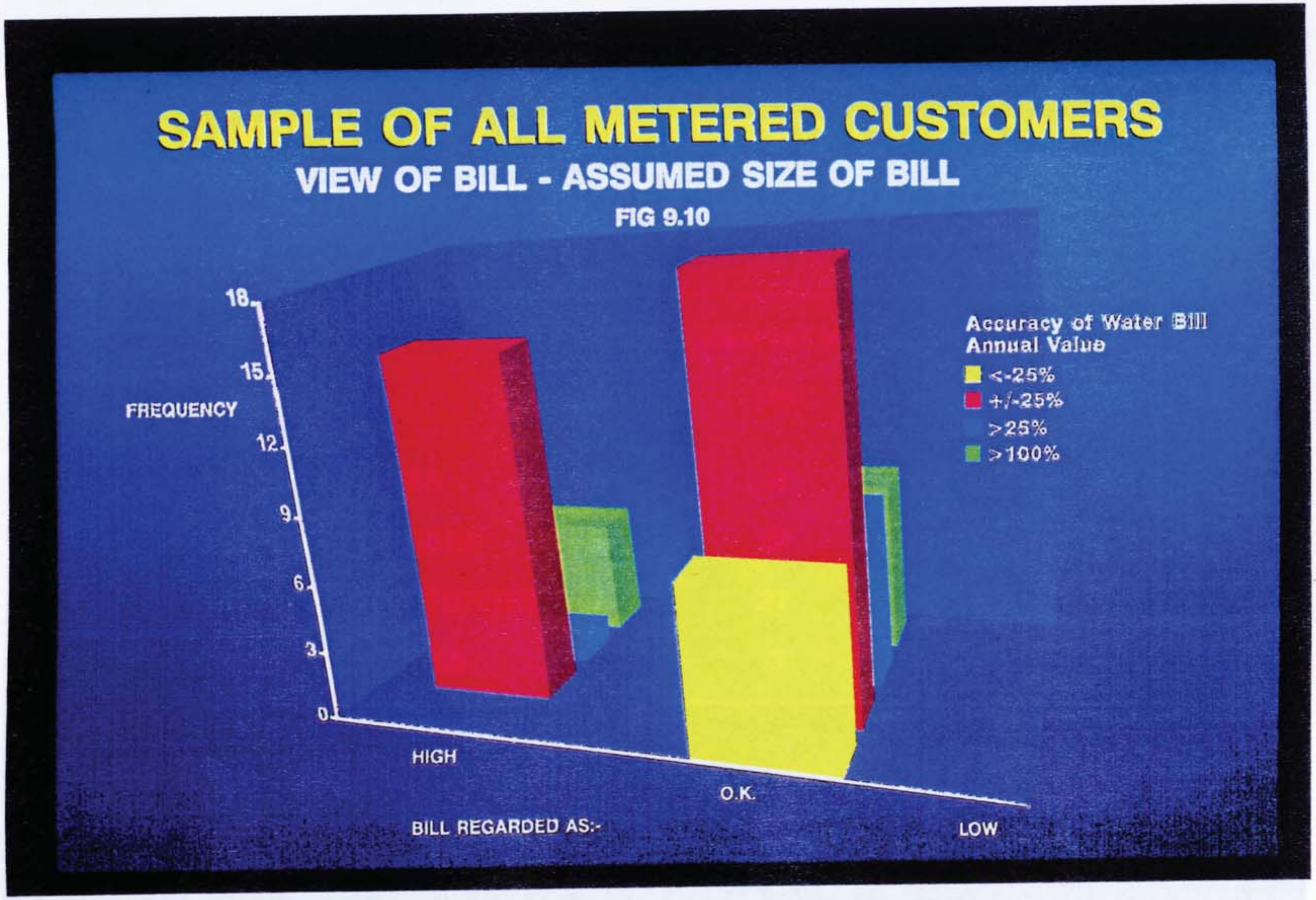
As with the major trade sample, customers were questioned to determine what measures were in use to conserve water. The options offered were: Recycling, use of economy devices, regular monitoring and a miscellaneous catch all category termed "other".

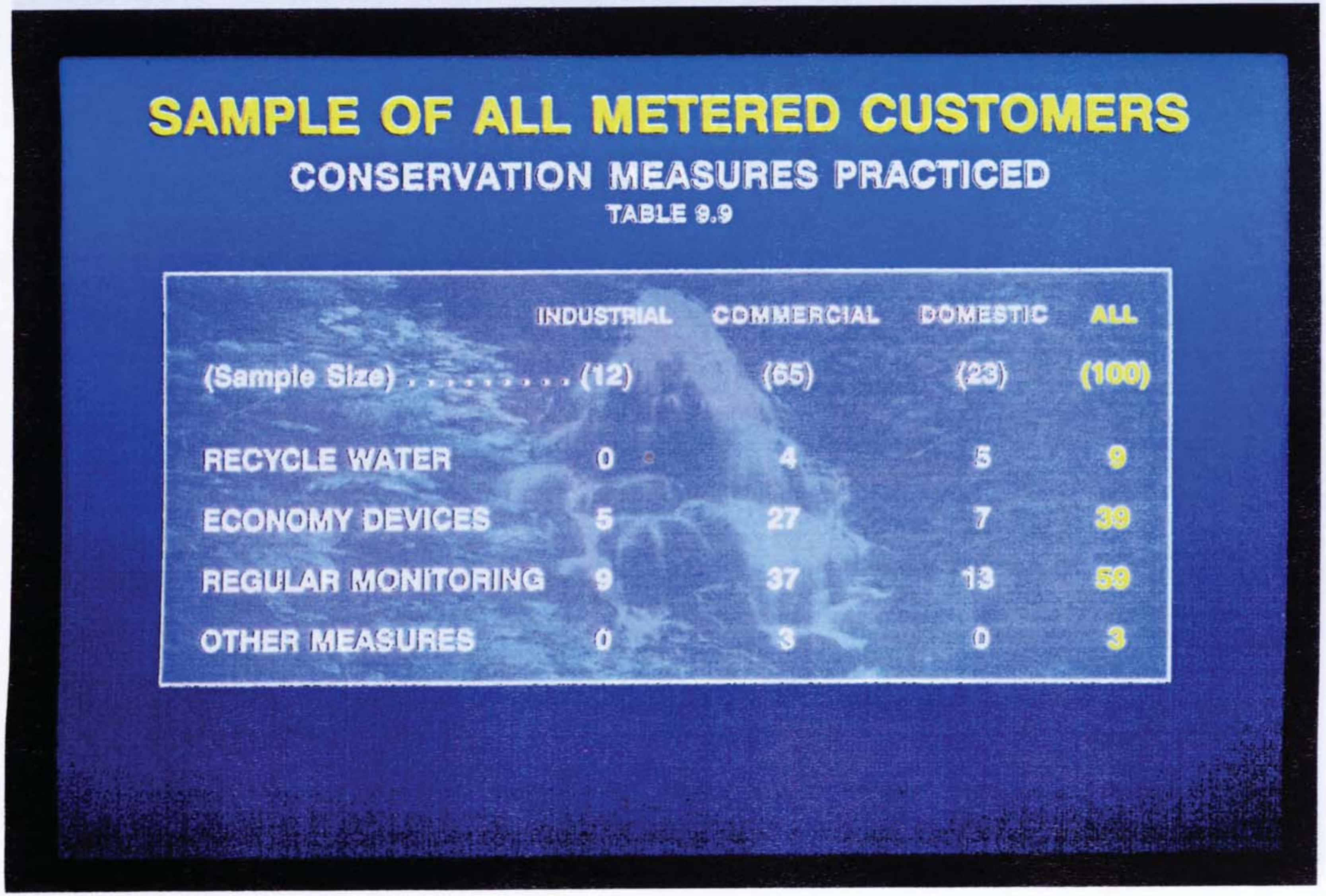
Tabulated results are presented as table 9.9 and graphically illustrated as figure 9.11. Of particular surprise was the ammount of effort householders say they gave to conserving water. To an extent these facts are comfirmed by virtue of the households having asked to be metered. Regular monitoring was the single most popular practice representing its low cost and ease of implementation.

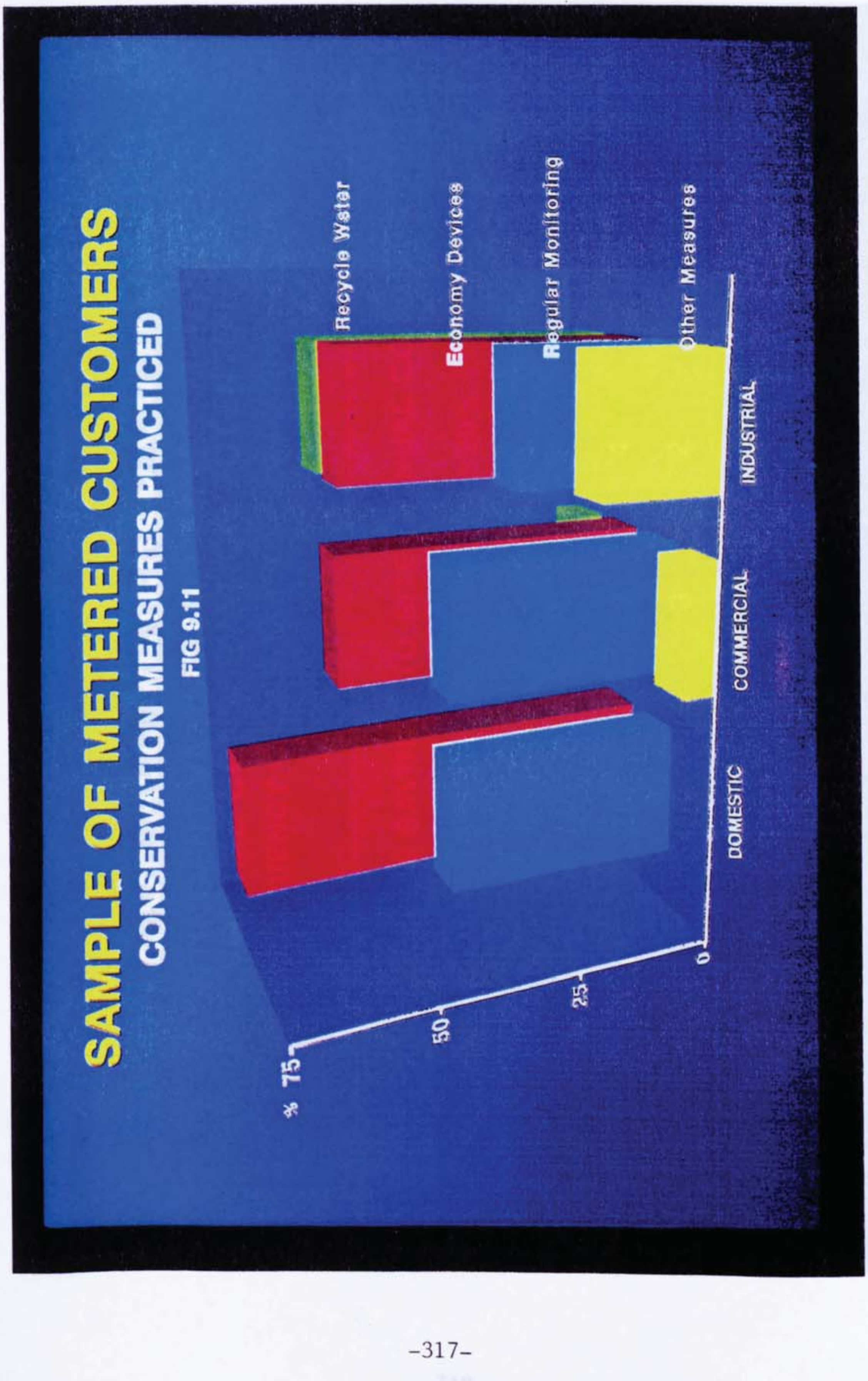
9.8.3 ASSESMENT OF CONSERVATION POTENTIAL

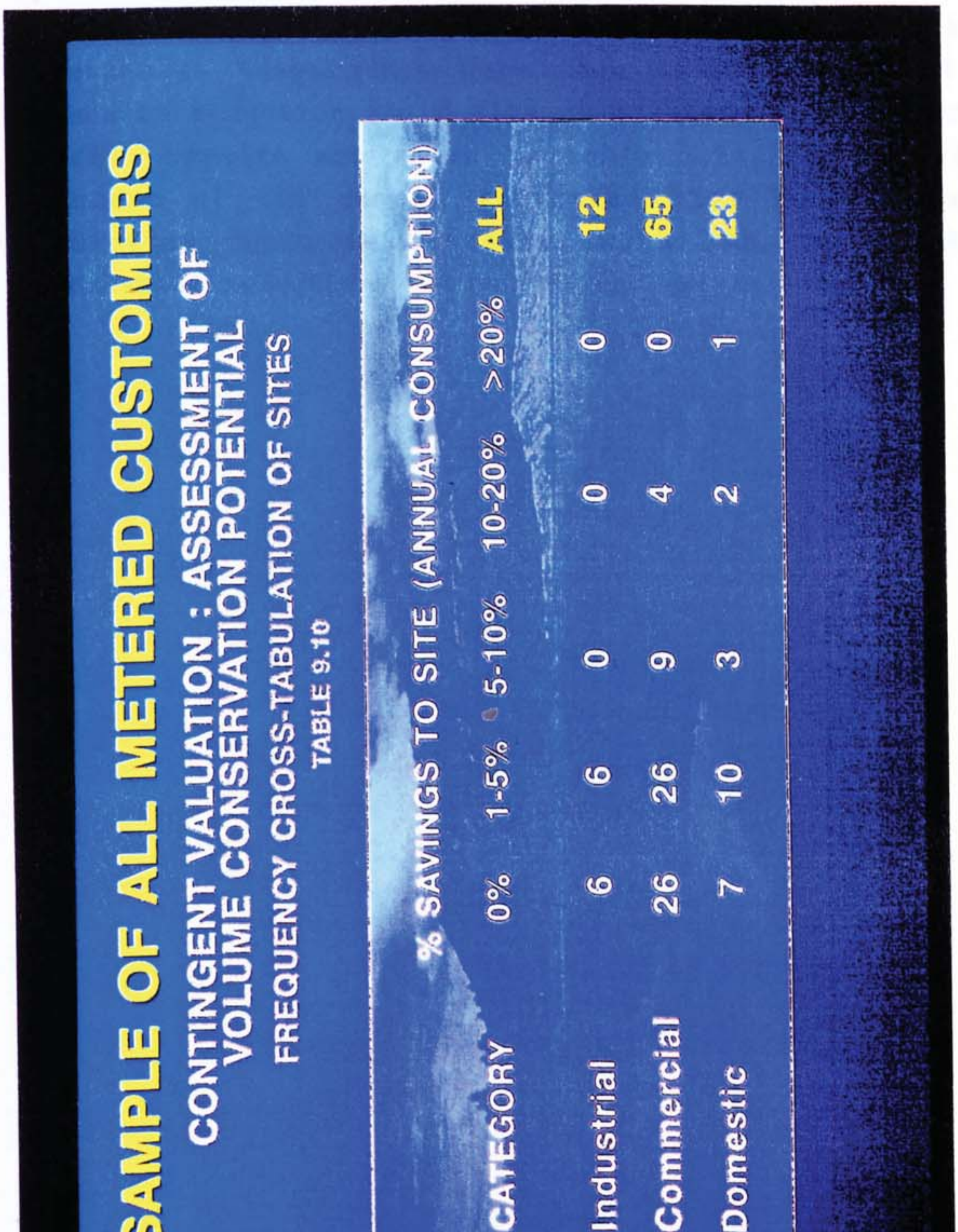
Contingent valuation approaches, based upon quantity and pressure, were applied to assess further potential for conservation. Customers were initially asked if they had a recollection of past appeals for public restraint of water consumption. In reply, 4 domestic, 6 commercial and 1 industrial customer gave authoritive answers.

The potential cost benefits of conservation were discussed, particularly in the light of measures already implemented by the customer. 40% of the complete sample indicated that no additional savings were possible, beyond those already in force. This was particularly true of industrial customers who could, in general, see no good reasons for reducing water consumption even during short term crisis. Table 9.10 summarises percentage response for each category of customer.


SAMPLE OF ALL METERED CUSTOMERS
VIEW OF BILL - ASSUMED SIZE OF BILL
FIG 9.10
FREQUENCY
18
15
12
9
6
3
0
HIGH
O.K.
LOW
BILL REGARDED AS:-
Accuracy of Water Bill
Annual Value
<-25%
+/-25%
>25%
>100%


SAMPLE OF ALL METERED CUSTOMERS
CONSERVATION MEASURES PRACTICED
TABLE 9.9
INDUSTRIAL COMMERCIAL DOMESTIC ALL
(Sample Size) . . . . (12) (65) (23) (100)
RECYCLE WATER 0 4 5 9
ECONOMY DEVICES 5 27 7 39
REGULAR MONITORING 9 37 13 59
OTHER MEASURES 0 3 0 3


SAMPLE OF METERED CUSTOMERS
CONSERVATION MEASURES PRACTICED
FIG 9.11
% 75
50
25
0
DOMESTIC
COMMERCIAL
INDUSTRIAL
Recycle Water
Economy Devices
Regular Monitoring
Other Measures


SAMPLE OF ALL METERED CUSTOMERS
CONTINGENT VALUATION : ASSESSMENT OF
VOLUME CONSERVATION POTENTIAL
FREQUENCY CROSS-TABULATION OF SITES
TABLE 9.10
% SAVINGS TO SITE (ANNUAL CONSUMPTION)
CATEGORY 0% 1-5% 5-10% 10-20% >20% ALL
Industrial 6 6 0 0 0 12
Commercial 26 26 9 4 0 65
Domestic 7 10 3 2 1 23

The final aspect, of the conservation assesment, centred upon pressure reduction to the site. Customer sensitivity was examined by establishing knowledge of remembered poor pressure incidents. For this sample such incidents were considered as relatively high being reported by 1 in 4 customers. Respondents were then asked what level of pressure reduction their site could stand on a permanent basis. Results are shown as table 9.11. Sixty eight percent of the sample indicated that some pressure reduction could be sustained with 29%, as a subset indicating reductions between 5% and greater than 20%.

SAMPLE OF ALL METERED CUSTOMERS

CONTINGENT VALUATION : ASSESSMENT OF PRESSURE REDUCTION POTENTIAL

TABLE 9.11

CATEGORY	SUBJECT TO LOW PRESSURE	% PRESSURE REDUCTION TO SITE					
		0%	1-5%	5-10%	10-20%	>20%	ALL
Industrial	4	4	3	3	1	1	12
Commercial	15	21	26	12	4	2	65
Domestic	6	7	10	4	2	0	23

CHAPTER 10

ANALYSIS OF HOUSEHOLD SAMPLE

10.0 INTRODUCTION

A description of the range of variables relative to the household sample was presented as Chapter 7. This chapter provides a summary of the output from the extensive and detailed analysis undertaken to test hypotheses developed in section 3.4. Headings are therefore presented in accordance with the hypotheses.

The development of the explanatory model is pursued through the text in a concise and logical manner, to explain its construction.

As detailed in section 4.1 variables and models are significant at the 95% level unless identified as otherwise.

The chapter concludes with a discussion of the model relating findings that evolved from the ongoing research.

10.1 SEASON

Meter reading was conducted at 9 points between September 1991 and September 1992. Thus 8 periods are included in the trial data.

To examine trends of consumption with respect to period the complete data set was assembled in two groups. Those households having "moderators" fitted and those with "open" supplies. Corresponding periods were summated across all household groups and converted to mean daily consumption per property.

The data is presented as figure 10.1 and shows little seasonal trend but marked variation about the mean values. In general households supplied without "moderators" consume more water and exhibit markedly larger variation.

To examine the existence of seasonal trends in greater detail the data was reassembled in two groups. Periods 1 to 4 (September to April) representing winter and Periods 5 to 8 (April to September) representing summer. Period mean consumptions were then computed for each case and the difference between summer and winter values obtained. A student's "t-test" was applied to test if the test mean (mu) equated to zero as indicated by figure 10.1. The hypothesis was initially rejected thus indicating that winter and summer means were significantly different.

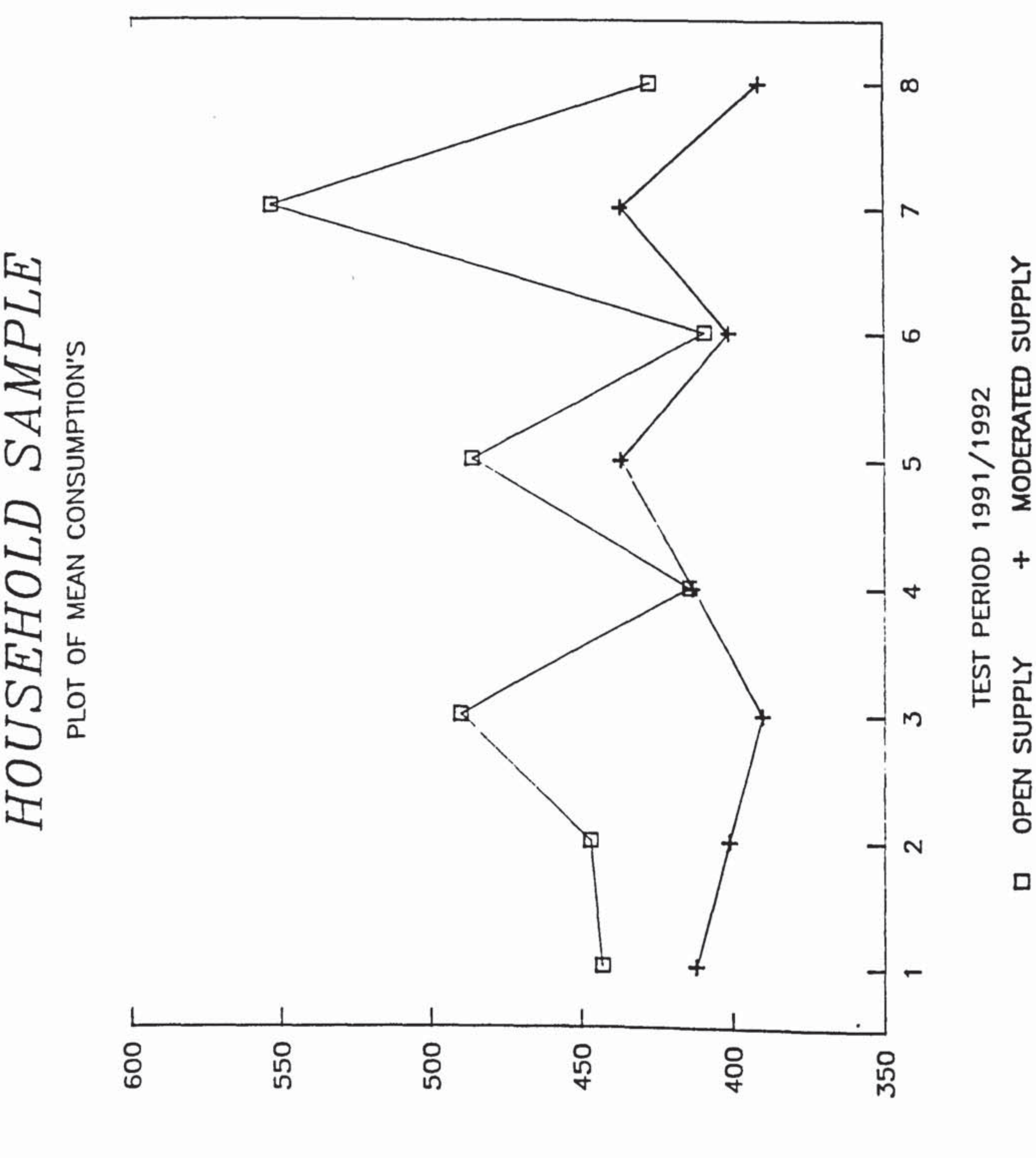
Upon inspection, the standard deviation of sample mean equated to 312 litres/property/day. Examination of the data revealed numerous distortions caused by the occurence of intermittent leagages on-property. The seasonal trend was further obscured by the fact that, during the last two period, moderators had been swopped between many properties.

To obtain a cleaner data sample only those cases containing no known leakages and supplied consistently, with or without a moderator, were included.

The t-test was repeated and results confirmed the zero hypothesis that winter and summer means were not significantly different. (Mean = 16.6, Std = 131.04, T = 2.10, P = 0.046).

To test sensitivity, the data was re-assembled with Periods 1 to 6 and 1 to 7 representing winter and correspondingly 7 to 8 and 8 only representing summer. In

Fig. 10.1


HOUSEHOLD SAMPLE
PLOT OF MEAN CONSUMPTION'S
LITRES/PROP/DAY
600
550
500
450
400
350
1
2
3
4
5
6
7
8
TEST PERIOD 1991/1992
□ OPEN SUPPLY + MODERATED SUPPLY

no instances did the test confirm findings other than winter and summer means were not significantly different. I.e. that the two extremes of season caused significantly differing sample on demand.

Details of the methodology are presented below:-

10.1.1 <u>"STUDENTS T-TEST ON HOUSEHOLD SAMPLE"</u>

Example of data assembled for periods 1 to 4 (P winter)
and 5 to 8 (P summer)

For each period average values, by individual case, were computed. The difference between winter and summer periods for corresponding cases were computed. Student's "t-test" was applied to test the hypothesis that sample mean (of the differences) corresponded to zero at the 95% level, i.e. for each case.

$$\frac{\sum_{P4}^{P1} P_i}{4} - \frac{\sum_{P8}^{P5} P_i}{4} = (d_i)$$

then

test (Mu) = 0 vs Mu NE to 0.00

<u>Results</u>

N = 251	SE Mean = 8.271
Mean = 16.588	t ratio = 2.01
STD = 131.04	p = 0.046

Thus the influence of changing seasons was shown to be not significant at the 95% level. As a consequence the data was carried forward for analysis without respect to season. In practice, due to the exchange of moderators at the conclusion of Period 6, the test was for all practical purposes split into two broad Periods: September to June 1992 and June to August 1992.

Despite the finding a representative variable, corresponding to the two seasons, was carried forward into the analysis. This enabled further checks to be made during model construction to independantly test effects of season on household consumption. Numerous models were forced to include this variable, to further test its significance, even when indications of low probability were generated.

At no stage did the variable prove to be significant at the 95% level but, of interest, prototype models assigned a value varying between 5 and 13.7 litres/property/day increase between summer over winter periods for the complete sample.

10.2 ON-PROPERTY LEAKAGE

Hypothesis number 10, derived in section 3.5 proposed that service pipe leakage was a significant component of household consumption. During the trial period 13 incidents of on-property leakages were definitely identified. It is probable that undetected background leakage was also occurring on a number of other households. Any such background losses are considered to be small compared to "major" leaks detected. The "major" leaks comprised; 3 leaks internal to the property (cistern ball-taps) and 10 hidden leakage on underground services. A summary of the major leaks is presented below:-

Acorn Group	Property Ref	Type of Leakage	Estimate of losses in l/prop/day	Period Leaking
C	60	Hidden	560	6 months
	71	Hidden	2,400	11 months
E	133	Ball tap + Hidden	4,400	5 months
F	142	Hidden	1,200	5 months
F	164	Hidden	3,000	11 months
F	171	Hidden (Repaired by SSW)	8,000	5 months
F	177	Hidden	2,630	5 months
F	178	Hidden	2,320	2 months
G	186	Hidden	3,420	5 months
G	190	Hidden	850	5 months
G	220	Ball tap	800	5 months
J	229	Ball tap	1,500	1 month
J	241	Hidden	3,800	5 months
		13 leaks TOTAL:	34,880	

The table shows that leakages ran for periods of 1 to 11 months. In general only if the leakage proved inconvenient to the customer was it repaired. Leakages occurred predominantly at properties in ACORN groups F and G, which are the two lowest grades of Council property.

Leakage occurred at a rate of 13 incidents to 516 households or 1 to 40 properties. The model indicated that leakage incidents were very significant (t = 20, p = 0) and ascribed a value of 1681 litres/day for properties with leakage occurring.

Fitting this value back to the frequency of occurrence yields an overall representative allowance of 42 litres/property/day. Spread over all properties in the sample.

If the variable is analysed individually and for properties supplied without a moderator, the value increases to 61 litres/property/day. This suggests that the Moderator has an impact equal to 19 litres/property/day in controlling on-property leakage. In practice this is considered to be unlikely unless the leakage rate approaches or exceeds the flow limit imposed by the Moderator. Leaks of such values would naturally be restriced by the physical effects of the Moderator.

15 litres/minute equates to 21,600 litres per day. The largest leak found in the trial sample was 8,000 litres/day. The difference in mean leak allowance for moderated/open supplies is in fact explained by the high incidence of leaks on group F and G properties; directly coupled with the fact that these properties were generally served via shared supplied and therefore only very few had Moderators fitted. It is concluded that the bias implicitly included within the sample is directly responsible for generating the difference in leak values between moderated and unmoderated supplies.

10.3 VOID PROPERTIES

A total of 12 instances were recorded. Of these only one household, reference number 117 was void for the complete period. The remainder became vacant for short periods, typically less than three months. Details are as follows:-

<u>OCCURRENCE OF VOID PROPERTIES</u>

ACORN GROUP	PROPERTY REF
*B	28
B	9
*C	61
*C	83
C	100
*E	105
*E	117
G	211

G	165
G	198
G	193
*J	249

Those households marked with an asertix occurred for longer than one reading period.

10.4 SHARED SUPPLIES

The hypothesis relating to shared supplied proposed that effects upon consumption would be significant. This was confirmed throughout the modelling process which consistently retained this variable as significant and as such was included in the final model.

The value attributable to the occurrence of a shared supply equated to -180 litres/property/day.

Models were also developed to examine consumption variables for the 160 properties, across ACORN categories, supplied directly with a dedicated service pipe as a distinct group. Predictive variables, at the 99% confidence level, in these instances were proven to be occupancy and the occurrence of leaks. This aspect is considered further in section 10.9 and, with respect to the subsequent checking of the model findings also discussed in Chapter 11.0.

10.5 PROPERTY AGE

The hypothesis that older households consume more water was indicted by the model. The most significant results attributed a range of consumption values from 0.5 to 1.30 litres/property/day, for each year following construction. Thus a property 50 years old could be expected to consume between 20 and 52 litres per day more than a similar property only ten years old. In the final models the variable was demonstrated to be significant, attracting a value of 1 litre/property/day for each year since construction.

10.6 SOCIO ECONOMIC GROUPING AND GARDEN AREA

The ACORN groupings were considered, in section 6.2.1 as determinates which potentially represented a wide range of independent variables. The six groupd covered from affluent suburban houses (group J), with large gardens to poorest council property, (group G), with concrete yards rather than grassed areas.

The model rejected ACORN groupings as a significant variable for all but category J households. For this group alone the variable was very significant and attracted an additional allowance of 217 litres/property/day.

Closer examination revealed a conflict, within the model, between size of garden area and properties in group J. Inclusion of only one of these variables improved the "F" value of the model. Inclusion of the "group J" factor enabled the strongest model to be generated.

Table 10.1 presents detail of properties per connection related to ACORN category for the sample and Table 10.2 tables plot size for each of the ACORN groups. Reference to the table demonstrates that all group J properties ahd gardens larger than 1000 m^2.

10.7 OCCUPANCY

Householders were interviewed to determine not only the fact of occupancy but also the number of adults and children in residence. The model retained each of these variables as significant.

Table 10.1

HOUSEHOLD/MODERATOR SAMPLES

PROPERTIES PER CONNECTION BY ACORN GROUPS

	1	2	3	4	5	6	7	8	ALL
B	112	0	0	0	0	0	0	0	112
C	68	16	6	0	0	0	0	2	92
E	60	10	2	4	0	0	0	0	76
F	0	14	0	70	0	2	0	0	86
G	2	14	6	56	0	2	0	0	80
J	80	0	0	0	0	0	0	0	80
ALL	322	54	14	130	0	4	0	2	526

Table 10.2

HOUSEHOLD/MODERATOR SAMPLE

PLOT AREA (M^2) BY ACORN GROUPS

SIZE OF PLOT, INCLUDING HOUSE (M^2)

	70	100	120	144	160	200	220	240	250	288	300	360	375	450	5000	1000	1200	1500	ALL
B	0	0	0	0	22	0	0	0	0	0	0	0	22	48	26	14	0	0	112
C	42	20	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92
E	0	0	0	12	12	0	10	0	0	0	0	42	0	0	0	0	0	0	76
F	0	0	0	8	0	0	0	0	0	46	32	0	0	0	0	0	0	0	86
G	0	0	0	0	0	14	0	18	26	0	0	22	0	0	0	0	0	0	80
J	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	26	36	80
ALL	42	20	30	20	34	14	10	18	26	46	32	64	2	48	26	32	26	36	526

Early models indicated that adults consumed typical values of 15 litres/day more than children. However, later models, which were significant at the 99% level, demonstrated that a combination of adults and children into a single factor, relating totals of people in residence, was preferred. The model ascribed a value of 23.7 litres/person/day to the variable termed "people".

Table 10.3 provides a reference for occupancy levels related directly to each ACORN group.

The hypothesis that properties unoccupied during the day used less water was not proven by the model. This finding indicates that the sample mean for properties unoccupied during the day is not significantly different from properties known to be normally occupied. Further questioning indicated two areas of further research, i) How and why do customers who are away from home for large parts of the weekdays continue to consume water at a rate equal to occupied properties; ii) Does the total daily "domestic" water requirement of a household who all leave home to attend work exceed that of households who (all or part) stay at home.

10.8 CONSTRUCTION OF MODEL FOR HOUSEHOLD CONSUMPTION

Two models were developed to represent significant variables which influence household consumption. The first model excluded rateable value as a factor, on the basis that this data will not be available for newly constructed properties. The second model was developed to include R.V. as a variable.

The analysis methodology described in section 4.1 was applied to determine intercorrelations, such as that existing between garden size and properties in group J reported in section 10.6.

Table 10.3

HOUSEHOLD/MODERATOR SAMPLE

HOUSEHOLD OCCUPANCY BY ACORN GROUPS

OCCUPANCY RATE (COMBINED ADULTS & CHILDREN)

		0	1	2	3	4	5	6	7	8	9	10	11	12	ALL
ACORN GROUP	B	0	8	56	22	20	4	2	0	0	0	0	0	0	112
	C	2	8	32	20	10	8	2	2	2	0	4	0	2	92
	E	4	8	38	14	8	4	0	0	0	0	0	0	0	76
	F	0	0	22	44	14	4	2	0	0	0	0	0	0	86
	G	0	0	18	42	14	6	0	0	0	0	0	0	0	80
	J	1	5	40	10	14	8	0	2	0	0	0	0	0	80
	ALL	7	29	206	152	80	34	6	4	2	0	4	0	0	526

	MIN	MAX	MEAN	STDV
B	1	6	2.69	1.06
C	1	12	3.5	2.47
E	1	5	2.4	0.98
F	1.5	6	2.9	0.92
G	1.5	5.25	2.96	0.77
J	1	7.0	2.83	1.29

The variance inflaction factors were also computed to further test for relationships during the modelling process.

The final model, excluding rateable value was:-

$$Q_d = 264 - 40.5(M) + 217(A) + 23.7(P) \ldots\ldots\ldots\ldots(11)$$
$$+1525(L) - 180(S) - 272(V) + 1.00(Y)$$
$$(R^2 = 51.1\%\ F = 79.23 p = 0.000)$$

where:- Q_d = Consumption in litres/property/day

M = Indicator variable for Moderator:
Fitted = 1
Not Fitted - 0

A = Indicator variable for households belonging to ACORN group J thus Group J = 1
Groups B, C, E, F or G = 0

P = The total number of adults and children in residence.

L = Indicator variable for known leakage.
Yes = 1
No = 0

S = Property supplied via. a shared supply
Yes = 1
No = 0

V = Indicator variable for void property

Y = Property age in years

For each term:-

	t-ratio	p	VIF
M	-1.60	0.010	1.0
A	5.81	0.000	1.1
P	5.30	0.000	2.6
L	21.35	0.000	1.0
S	-4.21	0.000	2.8
V	-2.46	0.014	1.0
Y	2.42	0.016	1.1
Constant	8.50	0.000	-

The high variance inflation factors exhibited by "P" and "S" were addressed if either factor was removed from the model. The relationship is explained by the association between each variable and the ACORN category F which links properties with a high occupancy rate and frequency of shared supplies. It is, however, considered that the inclusion of these two factors strengthens the model and allows wider application.

The model which includes rateable value and provided the best fit of variables was;

$$Q_d = 22.7 - 35.8(M) + 1.89(Y) + 9.64(P) + 0.970(R) + 1504(L) \quad \ldots(12)$$
$$(R^2 = 50.2,\ F = 83.52,\ p = 0.000)$$

where the additional variable (R) represents the household rateable value.

For each term:-

	t-ratio	p	VIF
M	-1.14	0.254	1.0
Y	2.76	0.006	1.5
P	2.75	0.006	1.1
R	6.11	0.000	1.6
L	19.14	0.000	1.0
Constant	0.29	0.773	1.0

Rateable value was shown by various models to interrelate to both void properties, shared supplied and ACORN classification.

10.9 IMPACT OF THE MODERATOR

The overall results for the complete trial sample confirm that fitting of a Moderator to households, including those served by shared supplies, yields consumption savings of between 35.8 litres (model 12) and 40.5 litres (model 11).

The existence of shared supplies has been demonstrated to reduce consumption by 180 litres per day. Such a limit imposed through the vagaries of the plumbing system is substantially in excess of conservation available from the Moderator.

A further model was developed to establish the impact of Moderators to properties supplied with a dedicted service pipe i.e. excluding shared supplies. Results were:-

$$Q_s=42.2-41.2(M)+1334(L)+98.5(P)+0.179(G) \ldots (13)$$

(Rsq = 53% F = 90.38 and p = 0.00)

where Q_s = Property consumption in litres/day
M = Indicator variable for representing Moderator
L = Indicator variable for leakage
P = Number of residents
G = Garden size in m^2

A detailed appraisal of the Moderator is presented in Chapter 11.

10.10 TESTING OF HOUSEHOLD MODELS

Further to the original trials, completed for 516 properties to September 1992, substantial additions to the sample were commissioned. The purpose was to test findings from the original models (ref 11,12 &13). This subsection also; describes the new household samples, analyses them to derive new models and, finally, contrasts these with the original findings.

Two new sample sets were pursued, ultimately accounting for some 1253 extra properties. Together with the original 516 household samples the total, 1769 properties, have been retained for long-term reference and monitoring.

The second phase, samples consisted of:-

700 Metered Households (paying by volume)
553 Extension to original household sample
(meters for monitoring only)

10.10.1 METERED HOUSEHOLDS PAYING BY VOLUME

From the companies billing records 700 households, who pay by meter, were randomly selected. This sample differs from the original household samples in two ways.

First; the customers pay for water by volume. It was therefore expected that perception of water used would be higher than in earlier samples, where meters were fitted purely for monitoring purposes, often without the customers knowledge.

Secondly this sample of households was charged by meter because, either; the properties were constructed post 1989, when rateable values were no longer available for new properties or; alternatively, the sample included householders who perceived some benefit and had opted for voluntary metering in pre 1989 households.

The sample was therefore expected to show some bias towards more careful usage of water, less leakage incidence, due to newer plumbing, and more exacting maintenance. These expectations were confirmed.

For the sample, meters were read on four occasions from September 1991 to February 1994. Data was collected on:-

Incidence of voids
Location of meter (Internal vs external)
Age of property
Occupancy density

Incidence of leakage
ACORN profile (B,C,E,F,G,J).
Presence of MODERATOR to limit flow
Incidence of shared supply.

The sample contained no ACORN group G (poorest council) houses; 383 group B , 3 group C, 100 group E, 17 group F and 31 group J properties.

This split approximates very closely to the entire metered household population contained within the Company's billing records.

By inspection, when undertaking meter reading, Moderators were found to be fitted to 101 households within this sample. In general this was accounted for by houses constructed after 1990 when Moderators were fitted to all new properties at the construction stage.

Due to property age and associated plumbing configuration 14, out of the 700, properties had meters located internally. This was due to either the prperty being fed via a shared supply or to meet customer requirements prior to the current policy of boundary metering.

Not one of the sample properties was supplied via a shared supply.

Leakages on property were clearly shown to exist on just two properties.

On at least one occasion during the two year monitoring programme 14 properties were confirmed to be void. However only the occurrence of voids was obtained and not the duration. Thus affected properties may have been void for anything from one day up to the total duration between successive readings.

Simple surveys were attempted with all residents of the 700 property sample. Questions relating to occupancy and adequacy of supply were asked. From experience, with the original samples, neighbours were also asked to confirm occupancy levels of adjacent households. Unlike the original sample, very little discrepancy was discovered. This was taken as a further indicator of "better class of property". Not one of the metered properties in this sample fell within areas recognised as being predominately occupied by ethnic minorities. Again this represents the bias of this sample towards properties that are newer and of higher socioeconomic groupings.

For the 492 households where occupiers could be contacted, and chose to answer the survey, the mean occupancy rate equated to 1.949 people per household. This is markedly lower than the company wide average for South Staffs Water (2.6).

For individual ACORN groups, property densities determined from the survey were:

ACORN GROUP	OCCUPANCY DENSITY
B	1.99
C	2.00
E	2.21
F	2.00
G	-
J	2.4

10.10.2 RESULTS FOR METERED HOUSEHOLD SAMPLE

The multiple regression approach detailed for the original samples was retained for analysis of the phase 2 households.

The most direct model was proven to be:

$$U = 152 - 138V + 69.1P + 278L - 68.2M \ldots\ldots\ldots(14)$$
$$(r2=52\%).$$

where:

V = incidence of void 1=yes 0=no
P = combined children plus adults in occupancy
L = incidence of leakage 1=yes 0 =no
M = application of Moderator.

Without an intercept the strongest model was:

$$U=-148V+69P+281L+149B+152E+118F+213J-70.2M\ldots(15)$$

where: B, E, F and J refer to ACORN groups.

An independent model was also generated to assess the varying daily consumption of households within differing ACORN groups and the effects of the Moderator:

$$U= 343B + 476C + 348E + 256F + 396J - 117M\ldots\ldots\ldots(16)$$

Thus "C" properties can be seen to consume more water per household than any other group. However there were only 3 ACORN group C households contained in the sample.

Upon investigation one C property had been void for approximately 40% of the test period. Its average consumption over the complete two year period, with no adjustment for being empty, equated to 375 litres/property/day. With the void allowance, from equation 13, of 138 litres the corresponding daily consumption for this property was 513 litres. This is high when compared to the sample mean of 326 l/prop/day. The second of the 3 group C samples consumed 676 l/property/day during the two year test. The latter household was revisited to question the occupants. It was a large, 80 year old, semidetached property with an immense garden. The occupants confirmed that, in-fact, they rented out a part of the land for a vegetable allotment with water being drawn from their property. The property's rateable value was £798, thus even with above average consumption, savings had been gained by transferring to meter in 1986.

The property age was shown by early models from this sample to decrease consumption at a rate equivalent to -0.7 l/prop/day. This was unexpected, compared to earlier findings which ascribed a value of +1 l/p/d for each year following property construction. The difference is most likely to be due to the maintenance undertaken by "proud" owner occupiers of "paying by meter" properties to protect their investment and to control unnecessary consumption to limit bills. The final model (14) took no account of property age.

This point was confirmed during the survey stage: Having got the meter, a number of customers at interview stated that regular monitoring, and even night time monitoring, was undertaken to check and control consumption. As a consequence only 2 properties out of the paying-by-volume sample where definitely proven to be subject to a leakage. This represents a ratio of 1 in 350 properties compared to 1 in 40 for properties not paying by volume (section 10.2).

Table 10.4 presents a cross tabulation of internal meters, occurrence of leaks and void properties by ACORN category.

The model determined that households with internal meters consumed 36.8 litres/day more than those with external. This conflicted with assumptions that household leakage

PHASE II MODEL CALIBRATION AND TESTING SAMPLE
CUSTOMERS PAYING BY METER VOLUME:
DESCRIPTIVE CROSS TABULATION WITH ACORN CATEGORY

	ACORN GROUP					
	B	C	E	F	J	TOTAL
INTERNAL METERS	7	1	1	0	5	14
OCCURENCE OF LEAKAGE	1	0	1	0	0	2
OCCURENCE OF VOID	8	1	3	0	2	14

PAC/ APRIL 94

TABLE REF. 10.4

often occurred between the footpath and internal stop-tap, i.e. the buried service (section 3,4 hypothesis 10). However, it can be seen from section 10.2 that the majority of hidden leaks, on the original sample, occurred on shared supplies within groups F and G. These were not represented in this second phase sample and the results are correspondingly different. Internal meters occurred predominantly on ACORN groups B and J. These represent the two most affluent household types in the sample and the positive value is therefore assumed to be linked to this fact. In the final model (14) representing this sample the incidence of internal vs external meters was not proven to be significant.

10.10.3 COMPARISON WITH ORIGINAL FINDINGS

The models in either sample are broadly similar. Each set identifies the same variables as statistically significant. Shared supplies were not included in the final model. This was due to the small incidence (5 from 700) in the sample. Early models did however select this variable and ascribed a value of -184 litres/property/day for its effects. This fact is considered further in sections 10.10.4 and 10.11.

	model 14 l/prop/day	model 11 l/prop/day
Constant	152	264
Void	-138	-272
Occupants	69	24
Leaks	278	1525
Moderator	-68	-41
Group J	0	217
Shared supplies	-180	-180
Prop'Age(per yr)	0	1

For the phase two, pay-by-volume sample, property age was determined, by the model, as not significant. In practice this is due to the combined effects of the majority of households being constructed after 1989 and, again, the control exercised by customers paying by volume.

The significant variables do, in some cases, demonstrate differing magnitudes. Assumption and findings explaining differences are included in section 10.10.2 above. Most notable is the difference between the value ascribed to household leakage in the sample of customers who pay-by-volume and those who are merely monitored. For example the difference in leakage between models (11) and (14) is 1247 litres/property/day. This was determined to be the direct result of social profile including occupier ownership, rather than landlords or local councils.

Customers paying-by-volume consumed an average of 326 l/prop/day compared to (147.9*2.6)=384.5 l/prop/day for properties in the sample of households metered but <u>not</u> paying by volume.

Of interest in this respect is the finding that conversion of the above figures, to represent per-capita, reveals more consumption per head in households paying by volume:-

Paying by volume: 326/1.949 = 167 l/head/day

Metered but not pay by volume: 384/2.6 =148 l/head/day

data from table 10.5

It must, however, be remembered that the second phase sample of customers who pay by volume has a markedly differing ACORN profile. In particular there are no group G properties and very few group C and F houses.

Application of Model (11) from the original research, section 10.8, to all complete cases (those completing full interviews) resulted in a prediction of 351 litres/property/day. Results directly summated from records, for the same cases, equated to a consumption of 330 litres/property/day. The difference, a 6% over prediction, is explained by the desires of customers paying by volume to conserve water.

10.10.4 500 EXTENSION TO ORIGINAL HOUSEHOLD SAMPLE

The 516 sample describes in chapter 7 was extended in September 1992 to embrace a further 553 properties. The additional sample will be referred to as the phase 2 household sample.

The combined consumption results for the phase 1 and 2 samples are shown as Table 10.5. ACORN group J remains as the largest consumer, at 173 l/hd/day, with group F in second place accounting for 167 l/hd/day. The reasons for above mean consumption are, however, very different. Group J consumption reflects lifestyle whilst group F consumption reflects a high proportion of on-property leakage. This latter variable accounts for 23 l/hd/day in group F and only 3 l/hd/day in J.

The sample was obtained randomly using the methodology described in section 7.1. I.e. from properties where boundary boxes have been fitted as part of a street by street maintenance (mains and service) replacement programme.

To obtain the information required to test the models developed in earlier sections ifnormation was required on voids, occupancy rates etc. An alternative approach was employed to shorten the vast amounts of time that had been required for previous house to house surveys. A

MONITORED HOUSEHOLDS NOT PAYING BY VOLUME
COMBINED HOUSEHOLD CONSUMPTION
FOR PHASE I AND II SAMPLES
EXTENDED TRIALS FOR THE 12 MONTHS; SEPTEMBER 1992 TO SEPTEMBER 1993

ACORN	PHASE	PROPS	ALL l/hd/d	WEIGHTED CONTRIBUTION	PROPS	EXC' LKG l/hd/d		SP LKG (l/hd/d)
B	1+2	183	127.160	21.768	179	122.360	21.347	4.800
C	1+2	204	131.330	25.062	184	119.195	21.376	12.135
E	1+2	135	148.220	18.718	129	138.798	17.451	9.423
F	1+2	287	167.010	44.838	280	144.175	39.346	22.835
G	1+2	148	140.033	19.387	144	132.949	18.660	7.083
J	1+2	112	173.293	18.156	110	169.929	18.219	3.364
		1069		**147.93**	**1026**		**136.399**	

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TABLE REF. 10.5

simple questionnaire was hand posted to each property during the most recent round of meter reading.

Respondents were requested to complete name, address and details of the numbers of occupants. This also generated replies concerning non-occupation, i.e. void property.

45 usable returns from 553 contacts were initially received. Customers in seven streets, split over the ACORN groupings, were revisited in an attempt to gain a greater return. This directly led to an additional 45 usable questionnaires being returned. In retrospect the effort required to undertake "remote" surveys combined with the poor quality and low numbers of responses was not justified. It is considered that a full house-to-house survey, as developed for original samples, would have been more efficient.

A description of the phase 2 household sample, by ACORN classification is presented as Table 10.6. The average consumption, in litres/property/day was 488 for the 90 households who responded to the survey.

Employing model 11, from the work documented in section 10.8, generated an overall mean consumption of 361 litres/property/day. Similarly model 14, section 10.10.2, generated 569 litres/property/day. Thus model 11 unpredicted by 25% and model 11 overpredicted by 16%.

A summary of the data and results for the 90 phase 2 survey respondents is included as Appendix I. Examination of the match between results for model 11 and data for this sample revealed a reasonable match except for two very large discrepancies when a known leakage was recorded. This indicates an overestimation of the leakage allowance for model 11. Application of model 14 addresses this point but the restrictive effects of

PHASE 2 HOUSEHOLD SAMPLE
(FROM 553 RANDOM HOUSES)
Cross Tabulation : Description By Acorn

	B	C	E	F	G	J	TOTAL
CONNECTIONS	10	21	8	28	12	11	90
PROPERTIES	10	30	30	85	35	11	201
INSTANCES OF LEAKS	0	2	0	0	0	0	2
INSTANCES OF VOIDS	0	3	1	1	0	0	5
INSTANCES OF SHARED SUPPL	0	6	8	25	8	0	47
OCCUPANCY	3	3	2.7	2.6	2.5	2.5	2.7

PAC/ APRIL 94

TABLE REF. 10.6

shared services are not included thus causing a net overestimation.

Adjustments of model 14 to include an indicator variable for shared service results in the following:-

Q = 152 - 138V + 69.1P - 180S + 278L - 68.2M...(17)

This combines the findings of models 11 and 14 and, in particular, addresses the effects of the high levels of leakage found in the original household sample. This is discussed in greater detail in section 10.11 below.

As demonstrated in Appendix I the predictive result for the phase 2 household sample using this model was 475 litre/property/day compared to the actual sample mean of 488.

10.11 DISCUSSION OF HOUSEHOLD MODEL

Variations in more than 50% of all the cases of household consumption are explained by the model. Actual variations in per property consumption are considerable and very significantly influenced by the occurrence of on-property leakage.

For example in the raw data for the original household sample household consumption ranged from 2 to 12319 litres/property/day. There were 39 cases of consumption exceeding 250 litres/head/day.

Leaks were positively located on 13 properties and may be the explanatory factor for some of the remaining group of high consumptions, but this could not be confirmed.

There is no doubt that installation and monitoring of meters enabled high consumption and leakage to be identified on 13 properties in the original household sample, at least earlier than normal, and with much greater certainty. It is probable that some proportion of leaks identified via monitoring by SSW would not otherwise have been identified.

To test this aspect, as part of the phase 2 extended trial, a team of fully trained and equipped leak location experts were asked to attend each of the streets where the known on-property leaks were occurring. 8 of the 13 leaks were traced without any prior knowledge of which properties were affected. Thus 4 (30%) leaks would have continued to waste water undetected.

With respect to the points raised in the Ilse-of-Wight debate (section 2.4.3); it is unlikely that a leak detection campaign in the phase 1 trial areas would have succeeded in locating more than 70% of hidden leaks without the telltale meter consumption.

Out of the 13 positive, and copious, leaks identified 2 ran for the entire original (phase 1) trial period of 11 months and, indeed, continued into the extended trial period. The average on-property leak ran for more than 5 months.

For the phase 1 sample the average leak value of 2683 (34880/13) l/prop/day related to an incidence of 1 in every 40 properties. Thus company wide, with approximately 500000 households, some 12500 on-property leaks may occur. This equates to;-

(12500*2683/1000000)*(5*/12)=14 Ml/day
on average across a year.

As demonstrated in section 10.10.3, the mean leak value for customers paying-by-volume was substantially lower.

Taking this factor into account actual hidden leakage for the household population will, in practice, be lower than 1 in 40. Further most leaks were demonstrated to occur on properties falling within the ACORN groups F and G. These are most commonly not only council houses but also fed via shared supplies. Groups F an G represent 21.9% of housing stock in the Company's area. Thus a 1 in 40 ratio applied to just these two groups generates leaks on 2500 properties. This approach, which is considered to be representative, yields total annual on property leakage of:-

$$(2500*2683/1000000)*(5/12)=3 \text{ Ml/day}.$$

In practice the on-property leakage rate is likely to be somewhere between the two extremes. The phase 2 household sample reported in section 10.10.4 confirmed the frequency of on-property leakage exhibited by the original household sample at 1:45. These however occurred on households within ACORN group C and were shown by model 17 to have a mean value of 278 litres/property/day. Group C properties are characterised by being "terraced", frequently fed via a shared supply but, unlike groups E, F and G, they are privately owned. The conclusion drawn in this respect os that older, terraced housing particularly if combined with shared supplies is very much more likely to be subject to a leakage. In addition, the size of the leak and the duration that such an incident will waait repairs are both greater for tenanted properties.

The models generally demonstrated that much unnecessary data had been collected. From the original samples and in subsequent testing on the phase 2 extended household sample equation 11 was proven to be reaonable but biased to over estimate on-property leakage.

CONSUMPTION MODEL FOR HOUSEHOLD NOT PAYING BY VOLUME

$$Q=264-40.5(M)+217(A)+23.7(P)+1525(L)-180(S)-272(V)+1(Y)$$

(model 11 section 10.7)

where Q= Consumption in litres/property/day.
M= Binary indicator variable for Moderator.
A= Indicator variable for ACORN group J only.
P= Total household occupants.
L= Indicator variable for leakage.
S= Property supplied via. a shared supply.
V= Indicator variable for void property.
Y= Property age in years.

Greatest dependency was continuously linked to leakage, occupancy and existence of a shared supply. The influence extended upon the model by ACORN group J was also significant. This determinate was shown to represent plot size which was used in several experimental models as a direct alternative. The final choice, in favour of "J", was made for the reasons of; simplicity, ease of obtaining the variable from either national records or visual inspection of the property and finally no detriment to the models robustness.

In addition to the above model generated from this research two further models were generated. From the extended trials undertaken on 700 household customers who pay for water via water meters came the equation:-

CONSUMPTION MODEL FOR HOUSEHOLDS PAYING BY VOLUME

$$Q = 152 - 138V + 69.1P + 278L - 68.2M \quad (14)$$

where Q = Consumption in litres/property/day.
P = Total household occupants.
L = Indicator variable for leakage.
M = Indicator variable for Moderator.
V = Indicator variable for void property.

The third model was subsequently proven to be the most robust model generated, for all purpose use, whether paying-by-volume or not. The model is calibrated for un-moderated supplies:-

GENERAL MODEL FOR HOUSEHOLD CONSUMPTION

$$Q = 152 - 138V + 69.1P - 180S + 278L - 68.2M \quad ...(17)$$

where Q = Consumption in litres/property/day.
P = Total household occupants.
L = Indicator variable for leakage.
M = Indicator variable for Moderator.
V = Indicator variable for void property.
S = Indicator variable for shared supply.

The fact that neither pressure or flow featured as significant in any of the above models was, initially, something of a surprise. Both variables were included to represent the potential of the Company's water supply system to provide water to the customer.

Pressure did feature in early models with values equating to -2.27 litres/property/day/metre head of pressure. Flow never featured in any model.

The range of recorded flows and pressures at household boundaries were:-

	MAX	MEAN	(MEDIAN)	MIN
FLOW (l/minute)	28	21	20	15
PRESSURE (m.head)	75	52	53	30

From research reported (Maddaus, 1987) in section 2.5.5.7, reductions of 30 to 40% in district pressure correlated with reported savings of between 3 to 6% on property. It was expected, therefore, to identify some correlation between consumption and pressure and consumption and flow in this research.

In retrospect there are a number of probable explanatory reasons for this unexpected finding.

The majority, >67.5% of all pressures recorded fell within the narrow range of 45 to 55 metres head. The difference between these values represents a reduction of only 18%.

The sample distribution was, therefore, weighted, in respect of relatively small variations in supply pressure.

This reflects the Companys long-held practice of managing pressures pro-actively. As a consequence South Staffordshire Water's average supply pressure, and the sample mean pressure, is approximately 10 metres head below that reported by Maddaus. Thus the sensitivity of the relationship between change in pressure and household consumption for the sample is reduced. This has the effect of further eroding the significance of pressure as a determinate.

Secondly the North American findings represent customers who were subject to both a change in supply pressure and notification of that change. Neither of these factors were present in the sample trialed at South Staffs Water. Both are considered to cause behavioural changes in consumption.

The third and final factor with respect to pressure, but equally applicable to flow, relates to the observations made in sections 3.1 and 3.3.1. that non-policy variables artificially cause limitations to customer demand. Typically this relates to the layout and condition of on property plumbing but many other factors may be involved.

The recorded flows and pressures considerably exceeded the minimum standards of 10 metres head at 9 litres/minute; measured at household boundaries. The minimum standards were selected to ensure customers could obtain reasonable delivery flow and pressure in response to their demands for water. For the sample, recorded flow and pressures were well above minimum. Secondly the presence of non-policy variables, limits the ability of customers plumbing to transfer water into their properties. When these two factors are combined the relationship between pressure, flow and consumption is altered. In practice the finding confirms the hypothesis that supply potential was maintained in excess of the households ability to demand water, section 3.4.

CHAPTER 11 APPRAISAL OF MODERATOR

11.0 INTRODUCTION

The findings generated from this research and analysis have indicated that the Moderator may provide a useful tool for the water industry. In particular it appears to offer two new strategies worthy of further consideration: A whole property "Demand Manager" and, more radically, the opportunity to be used as part of a customer selected "service-band" charging mechanism.

The demand under consideration relates to "domestic usage". This of course, as discussed in section 2.5, is defined as including water for cooking, cleaning, toilets and central heating. The research and this appraisal is particularly targeted to household consumption, although this need not be an exclusive approach.

This chapter presents an appraisal of the Moderator under the following headings:-

Technical
Social
Political
Financial
Further research.

11.1 TECHNICAL APPRAISAL

There are two aspects considered under this heading. The first relates directly to the performance of the flow Moderator itself: Secondly, options for techniques to house the Moderator in household supply lines are discussed to determine opportunities, operational requirements and associated costs.

11.1.1 PERFORMANCE OF MODERATOR

Sections 5.4 and 5.5 reported the investigations and findings undertaken during the development stage of the Moderator.

Aspects of maintenance requirements were examined by, initially, placing Moderators on supplies to 21 households, in June 1989. Subsequently an additional 129 households had Moderators fitted in November 1989.

On a regular basis, initially on a three month cycle, the devices were physically removed and inspected to monitor:-

1. Wear or breakdown of Moderator.
2. Build up of scale deposits or other debris restricting flow.
3. Conformation of levels-of-supply.

From July 1990 to date Moderators have been fitted to the majority of newly constructed property. These were principally households but by default included any property supplied with a 20 or 25mm diameter service pipe. In addition, when conventional buried stop-taps were replaced, with complete new assemblies, the opportunity to install Moderators was taken. The combination is estimated to currently extend to some 10000 households plus miscellaneous commercial premises.

As discussed in sections 5.5 and 10.4, the non-policy restrictions linked to shared service pipes were shown to limit supplies far more than the Moderator. The policy decision not to excacerbate this effect by fitting Moderators, to shared supplies, was, therefore, vindicated.

In September 1992 a further 500 Moderators were removed, from supply, for examination. This was repeated for an additional batch of 700 Moderators in September 1993. Many of these devices had been installed for more than two years.

No deleterious effects have been found on any Moderator removed for inspection. Thus to date no maintenance requirements have been identified for the Moderator. It is however considered likely that the nitrile rubber will become less flexible with age and wear.

A further concern, investigated prior to the first live installation of any Moderator, was the performance of the device under varying upstream, or inlet, conditions. This aspect was addressed and proven to be satisfactory in a series of laboratory tests. The findings, summarised in figure 5.1 and table 5.1, demonstrated the stable relationship of a fixed flow outlet when subjected to varying inlet pressures of up to 100metres head.

The fixed maximum flow selected for the Moderator's proving trials, at South Staffordshire Water, was 15 litres/minute. This value coincides with the Company's own levels-of-service and exceeds regulatory requirements.

The Moderators can be manufactured to provide maximum flows to any specified value between 5 and 28 litres/minute.

During the research one property (only) was deliberately subject to a Moderated value of 9 l/m. No undue effects were noted but it was subsequently determined that the customers buried water service pipe was partially blocked by corrosion build-up. The customer had, even without any Moderator being installed, lived with a maximum available flow throughput of approximately 9 litres/minute (section 5.5). Once this had been realised further tests were undertaken to determine if either a 15 or the 9 litre/minute moderator caused any compound effects to further reduce available supply. I.e. testing the interaction of a moderated supply and a proven, severe, non-policy restriction. Neither value Moderator caused any further reduction in supply to the property.

The performance of the Moderator has been shown to be very stable. The specification of maximum flow, in these cases 15 litres/minute, was repeatedly achieved in laboratory tests even with Moderators which had been fitted underground for up to three years. No maintenance requirements have been identified. Thus once installed, costs are limited to eventual replacement. This is assumed to occur as a function of to the nitrile rubber diaphragm hardening over many years. To fully research this point long-term accelerated testing is required.

The trials demonstrated that levels of service could be maintained substantially above regulatory standards yet water conservation could be achieved. The models, developed in section 10, demonstrated that typical reductions in average household consumption of 41 litres/property/day were experienced (68 l/property/d for paying-by-volume customers).

The combined effects of Moderators installed to multiple properties across a given district requires further research. In particular the effects upon peak demand for individual and groups of properties requires investigation.

11.1.2 INSTALLATION OF MODERATOR

For the purposes of all trials, undertaken at South Staffordshire Water, Moderators were fitted at the household/company boundary. This location is defined as occurring at the back of the footpath.I.e. where the "highway" ends and private property begins. Pipework beyond the boundary is owned by and the responsibility of owner/occupiers.

The boundary, or as close as possible, is normally physically identified by a main-stop-tap. This controlling device is the property of the Water Company. Its purpose is to enable the customer supply to be isolated. Normally customers are allowed free access for their own purposes.

To meet the research objectives of "whole property demand management", the boundary was readily identified as the most desirable location for the Moderator. Amongst other advantages the boundary position controlled not only all consumption within houses but also enabled demand external to the house, i.e. service pipe leakage, to be monitored and controlled.

From 1989 all new households, within the South Staffs area, were constructed with a "boundary-box", instead of a conventional stop-tap, at the boundary. Advantages offered by such an installation include the potential to fit water meters, monitor pressures/flows and to install/maintain/change backflow prevention devices etc.

Access to the boundary-box is through a conventional cast-iron or plastic box. Thus all that can be seen from the surface is a hinged box, approximately 150mm square, siting flush with the footpath surface. Once installed, all maintenance requirements can be undertaken without further excavation.

To take advantage of opportunities offered by the boundary box, the Moderator was engineered to sit in an industry standard housing which forms an integral part of the boundary box.

Thus the projects preferred location was achieved. A luxury, which formed part of my design requirements, was that the Moderator should be engineered to be capable of installation in boundary boxes together with the industry standard concentric meter. This objective was achieved and several thousand such combinations have been installed without any reported problems. The final design of the Moderator allows for easy, push-fit, installation and, if required, simple pull-out without tools extraction from the boundary box.

The provision of a boundary box is however an expensive option, especially when used as a maintenance replacement for conventional stop-taps. Typical UK costs for boundary box installation are reported, (WRC 1990) to be £200 per unit. For South Staffordshire Water the unit cost of this operation is approximately £150.

Installation of boundary boxes during construction of housing sites is much less expensive and much of the cost would be incurred by fitting conventional equipment. Estimates of the extra-over cost for South Staffordshire Water equate to approximately £30. This figure covers the more expensive purchase price of a boundary box compared to traditional stop-taps, some additional time for installation, and extra associated on-cost recovery (direct only).

For newly constructed property the installation of boundary boxes suggests itself as a reasonable compromise between pragmatism and cost. Once installed additional advantages are available. These include the facility for future meter installation at no additional cost, apart from provision of the meter.

For existing property, alternatives to conventional stop-taps are required to provide lower cost options. These have been investigated, developed and trialed as part of this research. A summary of installation alternatives and associated costs are presented below:-

Two choices presented themselves:-

1) <u>To locate the Moderator elsewhere.</u>
This is readily achievable. The moderator is small and can be engineered to meet most requirements. Its compact size enables the device to be fitted in-line; on pipe diameters down to 15mm (1/2inch). Consequently it could be located actually in the line of the pipe run.

The cost associated with such an installation escalates if an excavation is necessary to expose the pipework for modification. This is because of the high proportion of time (labour) costs, provision of bulk materials (stone etc.) and costly achievement of reinstatement standards (if excavation is in road or footpath). If a specific excavation is required it is probable that, in practice, most water undertakings would elect to spend slightly more and insert a boundary box and so gain the various associated benefits.

Many opportunities are, however, available to fit unobtrusive in-line devices to exposed plumbing. The most desirable location, after the boundary position, is adjacent to the rising main stop-tap. This is normally located where the buried service first rises above ground and enters the property. In the UK this is frequently marked by a stop-tap under the kitchen sink. Apparatus in this position controls all on-property consumption except for the buried service pipe between the boundary and rising main stop-tap.

Installation at this location is simple. Designs have already been completed and tested which allow incorporation directly into the existing stop-tap. Costs are substantially lower because of the avoidance of excavation. Limited testing, as an extension to this research, indicate, that if installed when either the stop-tap is first fitted or replaced for maintenance purposes, the net additional cost equates to approximately £6. No doubt with volume production this cost would reduce further.

Preliminary discussions with manufacturers indicate that stop-tap designs could be adapted to house the Moderator at an estimated cost of £5.00 including purchase of the Moderator.

The disadvantage of fixing the Moderator at this location is the loss of influence relative to the service pipe.

2) <u>To use alternative fittings at the boundary location.</u>
As detailed above, the small size of the Moderator enables varied installation packages to be achieved. The first choice of location remains at the boundary. This not only controls all on-property plumbing, including the buried service, but also ensures that the device remains the property of the water undertaking. Thus its initial installation and future maintenance can be undertaken without the need to disturb customers or enter onto private property.

A number of alternative devices have been purpose designed, as an extension to this research, to test Moderator installation at the boundary.

The approach described above for installation at or near rising main stop-taps can equally be applied to the boundary location. Hence new or necessary replacement of existing conventional stop-taps can be undertaken with modified equipment housing the Moderator. The extra-over cost for inclusion of the Moderator equates, in such instances to, an estimated £6, including purchase of the Moderator.

Alternatively, for the many stop-taps which remain unexposed, because they continue to function satisfactorily, a device has been developed and tested as part of this research. In simple terms the original stop-tap headwork is unscrewed and removed. The purpose designed headworks adaptor, complete with Moderator and new stop-tap headwork, is then screwed back in place. The result is a modified buried stop-tap at the customer boundary complete with Moderator and retained valve control for customer/company operation. The advantage of this approach is the ability to undertake this work without excavation. Thus costs are minimised to purchase of the Moderator, headworks adaptor and labour costs of installation. For limited trials undertaken at South Staffordshire Water the total of these costs has equated to approximately £65 including direct on-costs. Extended usage and bulk purchase is expected to see this cost reduce substantially.

The headworks adaptor has also been successfully trialed at the customers rising main stop-tap (under the kitchen sink) hence providing yet another alternative for installation, at much lower cost.

Summary of installation options and costs.

1) PURPOSE INSTALLATION OF BOUNDARY BOX TO HOUSE MODERATOR
   £150
2) EXTRA TO INSTALL MODERATOR AT NEW PROPERTY BOUNDARY
   £ 30
3) TO FIT INTERNALLY; PART OF REQUIRED MAINTENANCE PLAN
   £ 6
4) TO FIT INTERNALLY TO NEW PROPERTY
   £ 6
5) TO MODIFY EXISTING CONVENTIONAL BOUNDARY STOP TAP
   £ 65
6) TO FIT MODERATOR IN EX-WORKS STOP-TAP BODY
   £ 6
7) TO FIT IN EXISTING BOUNDARY BOX (with/without meter)
   £ 1

For wide-scale use the best compromise for installation of Moderators, without facilities for metering, would be option (6). This approach would entail a programme of Moderator installation at existing stop-taps which require replacement or as standard to all new properties.

Within South Staffordshire Water such an opportunity policy would take approximately 60 years to completely install Moderators to all property served by single feeds.

To speed the approach, selected areas could be tackled on a priority basis. Either those areas requiring resource development soonest or those areas supplied by the most expensive sources.

If boundary boxes are already installed or are being fitted for metering/monitoring purposes in their own right then extra costs for the Moderator are £1.

11.2 SOCIAL APPRAISAL

One of the concerns investigated in this research was that many customers are already subject to "restricted" water supplies. As demonstrated during the investigations and confirmed by the models these non-policy variables can be very significant. For example the presence of a shared supply was shown to account for a reduction in supply of 180 litres/property/day. Thus customers living in terraced property, particularly older council housing, are subject to a circumstantial effect which limits their ability to physically consume water.

The purpose of this approach, to determine a surrogate value for such non-policy restrictions, was twofold. First, to gain a measure of the magnitude of the effects and secondly to gauge customer reaction.

This enabled proposals to deliberately introduce a demand influencing device to be put in context. I.e. if certain customers could tolerate average daily restrictions equivalent to 180 l/prop/day what value of "restriction" could be introduced elsewhere.

The 15 litres/minute moderator was selected, speculatively, because of its correspondence with South Staffs Water corporate standards-of-service. However the fact that models associated typical savings of -40 litres/property/day were much greater than expected. This represents, approximately, a 10% reduction in household demand.

Un-modified flows measured at the boundary ranged from 15 to 28 litres/minute. 15 litres/minute left running all day is equivalent to 21600 litres/day. This represents some 48 times mean household consumption measured for the trial. It was anticipated that customers may have perceived that peak-flows had been "managed" but total consumption even with the Moderator installed could be 48 times greater. For unmetered customers there is no penalty to the customer for consuming this quantity of water.

Sources in the literature review indicated that the majority of consumption was accounted for by fixed volume activities such as the use of washing machines or toilet cistern filling. How then was 10% of household consumption saved ? It must be remembered that, in general, customers were not aware of the device being fitted or influencing their property. Savings were therefore spontaneous.

Large scale surveys were undertaken to question householders on occupancy profiles; but, one of the principle purposes of makingcontact was to determine if the customer had perceived differences in their water supply with the Moderator installed. The survey was undertaken a minimum of some six months after installation of the Moderator. Only in a very few cases were negative responses made. Indeed as reported in section 5.4, a number of customers reported improvements in supply.

This represents something of a paradox: Not only were supplies influenced by the Moderator, with typical reductions in consumption of 40 litres/property/day, but also, with very few exceptions, customers remained satisfied.

Reference to the breakdown of domestic per capita consumption, section 2.5.5.1, indicates the following:-

FIXED VOLUME USAGE	:	66 l/head/day
DISCRETIONARY VOLUME USAGE	:	80 l/head/day

Thus when converted to represent typical household consumption in South Staffordshire, some 216 litres/property/day is used other than directly with fixed volume equipment. It is, however, the case that some proportion of this quantity is used, for example, for baths. These traditionally have been assumed to be filled to the same capacity on each occasion. The findings of this research, however, indicate that perhaps filling of baths is much more time related than previously considered.

Certainly open appliance usage, such as showering and garden watering may be directly affected. These activities are recognised as time related and reduced available flow will create reduced consumption in any given fixed period.

The same argument holds true for leaks, which are also time dependant, but as discussed in section 10.11 the leaks found in the trials did not exceed 15 litres/minute. Therefore only when combined with simultaneous demand from legitimate household draw-off should reduced total consumption be experienced

As a proportion of "discretionary" volume usage (216 l/p/d) 40 litres represents 19%.

It is interesting to note that customers from the phase 2 trial pay-by-volume sample reduced consumption by a model value equivalent to 68 litres/property/day. Again this group of customers were not aware of the moderators presence yet they reduced consumption by 50% more than customers who were not paying-by-volume. This provides an additional clue as to how water consumption was conserved. It is reasonable to assume that paying-by-volume customers were already consciously making savings in activities like bathing and showering. Any extra savings must have been made without the customers awareness. This tends to confirm that savings are predominately due to time related activities with customers still taking the same time but flow throughput being restricted.

Further detailed research is required to determine the precise mechanisms leading to savings. It is likely that recording at each point of water consumption will be necessary before and after installation of a Moderator to obtain answers.

A surprising observation from the Moderator trials related to the lack of customer reaction to change. As detailed in sections 5.4 and 5.5 customers did not, in general, react to the reduction in level-of-service even when quite severe. This aspect probably reflects two factors: The first relates to 15 litres/minute providing a service which is well above a minimum acceptable to customers. The second relates to the stoic attitude of the public in "putting-up" with change.

Complaints concerning the Moderator have been limited to approximately 15 out of some 10000, and generally relate to extremes. For example were Moderators have been accidently installed on shared services.

The fact that 15 litres/minute generally appears acceptable provides grounds for additional research to determine customer reaction and measured savings to even lower levels of service. For example 14, 12 and 10 litres/minute.

11.3 POLITICAL APPRAISAL

Currently the industry is searching for an alternative to charging households by rateable value. Metering is certainly one option but the economic argument of cost versus savings does not encourage a universal approach.

One proven advantage of the Moderator is its ability to assist in the conservation of water. Equally the lack of concerns voiced by customers receiving "moderated" supplies indicates an unexpected level of acceptance. However it must be remembered that customers, in these studies, have not been made aware of the Moderator.

The principle of the Moderator appears to be acceptable. It conserves water, it lowers charges (directly for metered customers), and as a consequence it assists in avoiding the exploitation of some additional water resources.

If installed with metering on a large scale the additional cost is negligible (Less than one extra pound per unit).

An alternative approach provided by the Moderator stems from its ability to regulate maximum quantities of water to customers property. Thus customers could select a standard-of-service to suit their needs and pockets. This is envisaged starting with a basic service, which matches or slightly exceeds minimum regulatory requirements. Incremental levels would then be available, at a cost plus basis, ranging from the minimum to a distribution delivery upper limit. From the research the suggested range could be:-

SERVICE	Litres/Minute
BASIC	10
BASIC PLUS	12.5
STANDARD	15
STANDARD PLUS	18
PREMIER	25+

The relative charges would, to some extent, be dependant upon the numbers of customers opting for each level. In theory the "average" charge could remain as at present depending upon the business strategy adopted.

The approach can be incorporated with metering to gain the advantages offered by both systems or Moderators could be used as a charging device in their own right.

One concern about this concept is explaining the philosophy to customers. Considerable thought and research is required to determine a sensible approach and to determine a likely percentage uptake by customers across the suggested levels of service.
The benefits would be:-

Substantially lower gross installation costs
System requiring minimal maintenance
No associated costs of reading and billing
Fixed charges known to customers
Reduced water usage
Savings in revenue and capital costs
Environmental advantages
Standardisation of levels of service
Customer can select level of service

11.4 FINANCIAL APPRAISAL

Making use of the costs identified in the technical appraisal enables a financial appraisal to be undertaken:-

Three Models are presented in Appendix J: Model 1 examines the case of Moderators included within boundary boxes which are being installed to new property. The cost is therefore only £1 extra as specified in section 11.1.2 case (7).

Model 2 completes the same exercise but using the costs given in section 11.1.2 case (2), I.e. the extra cost for provision of boundary boxes, complete with Moderator, for new properties.

Model 3 provides a financial appraisal for the Modertor when fitted to external, conventional, stop-taps which require replacement with similar equipment. Costs are in accordance with section 11.1.2 case (6).

The models are based on a programme of installing 500 Moderators each year. From the research, undertaken in this thesis, adoption of the 15 litre/minute standard Moderator was demonstrated to yield savings of 40 litres/property/ day. Thus 5000 @ 40 litres equates to 0.2 Ml/day. From the Metering Project Group Final Report (Capener and Carnell, 1993) the long-run marginal cost of water was calculated as £58000/Ml/day/year. This figure included the direct costs, only, to South Staffordshire Water Company of items relating to resource acquisition, development, licence, treatment and distribution. Hence the direct benefit of the illustrated Moderator installation programme equates to £58000*0.2 = £11600. This figure is used as the annual benefit for each 5000 Moderators installed. The 8% cost of capital is taken as the private cost of capital to South Staffordshire Water Company.

The financial appraisal was initially undertaken assuming a ten year programme. Costs and savings were therefore dealt with in this period. In practice the savings from each year would extend until such time as replacement of the Moderator was required, i.e. an assumed 50 years. The Net Present Value would therefore be substantially higher than illustrated in the models. However a cash flow approach was selected to represent medium-term (10 year) costs and benefits.

Unit expenditure of either £1 (Mark II) or £6 (Models) is shown by the financial appraisal to offer pay-back periods of approximately 1.4 and 3.0 years respectively.

Of course once installed the benefits offered by the Moderator contribute until they require replacement. As a consequence the 3 models presented as Appendix J represent a short term assessment, only of costs and benefits and substantially undervalue the Moderators. For example in Model 2 the annual investment required to fund 5000 Moderators equates to £150000. However the model provides no benefits for Moderators fitted in year 10 and only 9 years worth of benefits for Moderators fitted in year one.

To address this point and assess long term benefits the following cash flow profile calculates the viable installation cost for the one-off installation of 5000 Moderators.

If cost = £X, then cashflow profile is:-

	Year 1 £	Year 2 £	Year 3 £	..... Year ∞ £
CAP COST:	5000*X	0	0	0
BENEFITS:	0	11600	11600	11600

$$NPV = 0 \text{ when } 5000*X = £11600 \left(\frac{1}{1.03} + \frac{1}{1.08^2} + \ldots.\infty \right)$$

$$= \frac{£11600}{0.08} = £145000$$

<u>Therefore X = £29</u>

Thus at a cost of up to £29 the model demonstrates that the installation of Moderators is viable i.e, NPV > 0.

This represents a very different outcome from that presented in Appendix J, Model 2 and serves to demonstrate the value of the longer term benefits of a Moderator installation programme.

The 15 litre/minute flow rate selected represents a relatively mild level of demand management. The introduction of more severe flow limitations would generate benefits in excess of those quantified in this research and at no additional installation cost. Thus benefits would increase, costs remain as modelled and NPV increase correspondingly. Such a measure would enable installation costs in excess of £29 to be considered viable. However the affects upon and acceptability to customers remains to be ascertained.

11.5 FURTHER RESEARCH

To complete understanding of the benefits and application of the Moderator some further research is required. This will complement the first stage of development and implementation generated by this research. Detailed study is required to:-

1) Examine the altered mechanisms and patterns of water consumption which account for the savings achieved when households supplies are subject to the Moderator.

2) Determine the effects upon peak flows when Moderators are installed on a large collective group of households.

3) Obtain a measure of the life expectancy of installed Moderators through accelerated testing.

4) Undertake a detailed economic analysis addressing the wider issues of national water conservation, effects upon effluent treatment etc.

5) Investigate the application of Moderators to form a charging mechanism.

6) Investigate the industry and customer acceptance of the Moderator both as a demand management tool and as a potential charging mechanism.

11.6 SUMMARY OF MODERATOR APPRAISAL

From all aspects considered, the Moderator appears to be an attractive proposition. The research has shown that customers can be subject to a "mild" conservation measure and accept its impact without apparent concern, this is despite a reduction in levels-of-service.

One concern, of customers, expressed in section 2.4 was that the environment was protected. Equally customers would like to be charged on an equitable basis.

The Moderator can assist in both aspects, first by reducing mean household consumption by, typically, 40 litres/property/day and secondly by enabling customers to select a level-of-service appropriate to their needs and pockets.

An economic appraisal, as outlined in the items for further research, is likely to demonstrate enhanced benefit when compared to the financial appraisal. This would be because of the longer-term and much wider national issues that could be taken into account. For example, meeting customer price and environmental care expectations, reducing effluent treatment and obviating the need for the costly billing process demanded by metering.

CHAPTER 12

SUMMARY OF FINDINGS AND CONCLUSIONS

12.0 SUMMARY

This research evolved principally around the identification, development and application of a device which offers potential for controlling customer demand. The device, now known as a "Flow Moderator" was proven at all stages of the trial to reduce the amount of water consumed by household customers. Typical savings were demonstrated to be 40 litres/property/day. However 68 litre/property/day reductions in conservation were modelled for customers paying-by-volume.

To establish the effects of the Moderator, other variables potentially influencing household water consumption, were identified to determine those which were significant. A comprehensive list of policy and non-policy variables was initially generated by reference to sources detailed in the literature review.

An integral element of the research was to examine the hypotheses that household water consumption can be modified whilst maintaining customer satisfaction. In the majority of cases, exceptions being limited to a number of properties supplied through a (communal) shared service, no adverse customer reaction was forthcoming.

With respect to shared services, the limitations imposed upon supply were demonstrated to be equivalent to 180 litres/property/day. Such a level of restriction is considered extremely high and had not been previously quantified. In contrast, households identified as ACORN group J were ascribed an additional value of 217 litres/property/day compared to all other socioeconomic groupings included in the trials. This extra quantity represents the additional usage of water for a range of requirements, including greater watering of larger gardens and to maintain a higher standard of living.

The consideration of just these two variables identifies a gross difference approaching 400 litres/property/day between extremes of socioeconomic property bands included in the houshold samples.

The levels of leakage identified as occurring on customer property further demonstrated conservation potential. However, it must be noted that customers have little reason to repair such faults unless they are inconvenienced. For Managers in the UK water industry, the household leakage was particularly linked to properties serviced by a shared water service and not owned by occupiers. Two ACORN groups in particular F and G (poorest council houses) provided evidence of high incidence of relatively large leaks.

The determination of a precise allocation between leakage and actual consumption was especially complicated for households in ethnic minority areas. Whereas typical occupancy densities were 2.6 to 3 people/house, in these specific areas, up to 19 people (adults and children) resided in one house. Levels of occupancy, in such instances, were not revealed by interview or questionnaire but only by inexplicably high consumption for property with no apparent leakage. This point should be born in mind by Manager attempting to reconcile water consumption in districts characterised by ethnic cultures.

Occupancy was demonstrated to be consistently significant factors in all models. However, the split between adults and children was not proven to be significant contrary to earlier research.

For the household sample, a number of other variables were demonstrated not to be significant in respect of influencing consumption. This included flow and pressure which is seemingly contrary to the laws of hydraulics. However, within the bounds of supply adequacy, maintained by South Staffordshire Water, the measured variations were not significant compared to the extremes imposed by either shared supplies, leaks, application of the Moderator, occupancy or affluent group J properties. Pressure and flow are discussed at length in section 10.11.

For properties included within the samples covering customers paying by volume the explanatory models were surprisingly uncomplicated. Models for all classes of consumer demonstrated that the number of people on site or at home was a significant factor. In addition, site size for household and industrial customers was significant. In the un-metered household sample, site size was represented by the surrogate of ACORN Group J.

Thus the two differing approaches adopted for the metered (paying-by-volume) customer samples and the ACORN household samples independently selected similar predictive variables.

The wealth of data collected for the metered samples proved unnecessary. However, the data obtained for comparative assessment of, for example, trends in turnover and employment by major customers remains unused.

Customers generally declared themselves to be concerned about levels of charges for water. The data collected, however, did not support this view. Unrealized on-site water conservation was identified by customers at interview. Further, having been presented with a real rise which was 10% ahead of inflation, customers had not reacted to the stimulus to conserve water usage in the manner claimed at interview. Comments offered by a pragmatic Chief Engineer of a major manufacturing concern probably best sum up this aspect of the work:

"I would rather save 5% of the cost of my electricity bill than 50% of my water bill.

The contingent valuation approach adopted to assess potential for conservation and to determine price elasticity were in practice considered unsuitable. Customers of all classes were either not able to assess the questions, which were subjective, or alternatively provided the answer which was judged politically correct.

Conservation within the major customer group was, however, generally assessed as good. Major schemes had been implemented which had the effects of requiring less product from South Staffordshire Water. Of particular note was the level of water recycling plant in use, to such an extent that various models identified larger consumers through the occurrence of this variable. Equally, the practice of regularly checking site consumption was undertaken by 72 of the 89 major customers and many houshold customers who pay for water by volume.

Of the 15 hypotheses formulated in chapter 3, three were not supported by the research. Two related to trade customers:-

SIC codes and patterns of working were not shown to be significantly representative of consumption.

For households, the fact of being at home during the working day did not prove to be significant in relation to consumption.

12.1 CONCLUSIONS

The evidence of the review and research is that conservation for all classes of customer is attainable. As argued in Chapter 2, the difference between water required for basic needs and "average" consumption provides the basis for savings.

The four approaches to achieve conservation, pricing, operational control, regulatory and education can be harnessed together to satisfy the requirements of all parties, including the environment.

Substantial evidence summarised in the literature review and subsequent research confirmed that many functions around the home or at work can be undertaken with less water and should be pursued through regulation where necessary. An example is the use of low-flush toilets.

With respect to water, payments relating to volumes consumed are a logical step forward. The conventional approach is to use water meters as a basis of equity. However work reported in section 2.4.3 indicated that the benefits of metering do not justify the costs. Alternatives to metering have the substantial benefit of reduced capital and operating costs.

At some point it is likely that positive action to conserve water will be required. In time, this option will cease to be available at realistic cost, of either environmental or financial consideration.

A device, such as the Flow Moderator, could very well be used in conjunction with any charging scheme, including metering, to provide a conservation balance. If used on its own it evens out flow regimes so that customers receive constant and equitable levels of service. If used in conjunction with a licence fee the Moderator would assist in providing equitability between customers of differing classes. Most radically of all the Moderator may provide the opportunity of a compromise between volume related and licence fee. The use of the Moderator as a direct basis for charging provides both the customer and utility with a novel charging mechanism. Customer could select fixed levels of service and pay an appropriate charge. This as, discussed in Chapter 11, may provide an answer to the paradox generated by the requirement of water service customers, who require acceptable service and price together with environmental care.

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1. Original Aims of Hypothesis

Original Aims

To investigate the acceptability and benefits of charging water consumers by an "equitable" method.

Original Hypothesis

i) That the current method of charging for water services is inequitable when compared to other utilities.

ii) That the provision of a water meter would be desirable.

iii) That propriety meters, currently available, do not provide sufficiently accurate measuring facilities.

v) That consumers, particularly dometic, would alter their consumption habits to reduce volumetric charges on metered services.

vi) That metered quantities of potable water would provide a good mechanism to base charges for sewerage.

vii) That provision of water meters could significantly reduce overall peak demands.

viii) That provision of water meters would be expensive and result in the need for sophisticated data handling and consumer information techniques.

P. A. Capener
December, 1985

SUMMARY OF PROPOSED RESEARCH DETAILS

General area of interest:- charging policy and analysis of demand for water services.

Provisional title of proposed research:- the acceptability and benefits of charging consumers by an "equitable" method.

P A Capener,
March 1985

SUMMARY OF PROPOSED RESEARCH DETAILS

Provisional Outline of Research Activity

There is a trend within the Water Industry to attain a more equitable method of charging consumers for services provided. South Staffordshire Waterworks Company provides a potable water supply only, although acting as agents for Severn-Trent to collect sewerage and environmental charges.

I propose to restrict my research to the analysis of potable supplies only and to initially split the project into two broad areas:-

A. Charging Policy

An indepth analysis of the Company's existing charging policy, split into domestic and trade consumers subdivided into metered and non-metered accounts, will form the backbone of the initial study. Comparison with both other water supply undertakings and non-related service industries will be made to assess peculiarities and anomalies.

Investigation into the possible methods of charging consumers will be made in order to assess their suitability from an equitable and economic point of view. I anticipate that a number of alternatives will become apparent and those of particular merit will be investigated in greater detail.

B. Analysis of Demand

A limited amount of work has been carried out in this respect with the Water Industry on a national basis. The principal source of information regarding demand data is the Water Research Centre, based at Swindon. I expect that close co-operation between myself and the WRC will be of mutual benefit. Reference will be made to numerous documents reporting historic investigations such as "The Accuracy of Small Diameter Revenue Meters for Monitoring Metered Supplies" and STWA "Malvern and Mansfield Studies", see Appendix 1 for a brief literature review.

The area of research would be to assess and report on current local and national demand levels for potable water. This would be broken down into domestic and trade consumption.

The two separate areas of research would then be combined into a single theme; that is the adoption of an acceptable charging system tied to a break even analysis based on (i) economics and (ii) available maximum supply quantities, from both the consumers and the utilities points of view.

At first sight the provision of a meter to physically record each and every consumption appears to be desirable; there are, however, a number of drawbacks as follows:

(i) Meter Accuracy

The types of meter available for general purpose recordings are of a low order of accuracy at low flows, ie ± 5% < 30 litres/hour. In addition, lack of regular maintenance could mean that some meters may be recording ± 50% across the complete flow range.

(ii) Alterations in draw-off habits

As far as I am able to ascertain, there has been little research into this specific area. However, early indications are that consumers, particularly domestic, may reduce their consumption in an effort to reduce the "bill". Also due to (i) above low flow draw-offs may not register on the meter.

(iii) Related Charges

SSWW Co act as agents for the collection of environmental and sewerage related charges. Investigation would need to be undertaken to see if these charges, which are based on rateable value, could be assessed more fairly on measured potable supplies, ie water in = water out of the property. see publication by Roger Freeman (MP) "A Fair Deal for Water".

(iv) Charging Policy

The present system allows for the accurate prediction of annual revenue from non-metered supplies based on known rateable values. A change in charging policy, on a large scale basis, could lead to initial uncertainties in revenue returns until a pattern is established.

On the plus side, however, with mass metering installed predictions of peak flows for any given system should be more accurate. Particularly, if meters are installed tied to a charging policy within permitted bands of maximum available supply (either flow or pressure regulation).

(v) Data Handling

A technical aspect which would require some consideration from a practical point of view, ie

(i) Remote reading; to reduce manpower and allow any monitoring period to be selected, thus assisting in analysis for leakage control and long-term predictions.

(ii) Head Office resources; anticipated that the amount of work required to monitor and bill the consumer could be reduced but that the system would require increased automation and a greater degree of sophistication.

Each of these sub headings would form part of the research project.

Summary

In the last few months this particular topic has been the subject of many discussions in Parliament, it is therefore very relevant both from specific technical and historic data reviews and as a social project from the consumer's point of view.

From an ethical standpoint; a physical monitoring policy is desirable, however, who would pay for the enormous cost of meter installations? (ie approximately 400,000 domestic applications in SSWW Co's area alone). If the Company were to charge for meter rental, as the gas and electricity boards do, what would be an acceptable cost to the consumer?

Currently water undertakings are obliged, under statute, to offer a metered supply option to all of its historically non-metered consumers. In the two years that this facility has been available only 320 consumers have taken advantage of the offer. These provide valuable research data and may help classify the desirability of universal metering as part of a specific charging policy.

P A Capener
March 1985

PRACTICAL CONSTRAINTS & WORK CONTEXT

Introduction

My research project has to operate within the realistic resource constraints, of cost and time, imposed by my sponsors and employers, South Staffordshire Waterworks Company. In addition, because of the progressive investigations into charging methods, I have to be aware of existing legislation particularly where individual water consumers are concerned.

As a researcher adopting a sponsored "part-time" approach my project philosophy has to be both acceptable and relevant to my employers. It must treat the subject with respect to current and future political climates; particularly in the light of Government proposals for privatisation and the trend towards extending domestic metering.

Practical Constraints

Applying statistically acceptable samples to each of my revised hypothetical categories yielded some 1000 domestic properties requiring metering. At an estimated cost of £100/unit the total cost was totally impracticable. A realistic and workable approach was required minimising experimental costs. This indicated an approach to the investigation of examining existing metered accounts, applying multi-categories to each sample and reducing experimental categories. This is the method that will be adopted and despite the obvious disadvantage of erosion of experimental quality, yields tremendous value for money and is acceptable to my employers.

Two other constraints allied to the number of consumer samples are time and existing legislation. The fitting of 1000 domestic meters would within existing schedules, have imposed excessive workloads and led to a protracted installation period, perhaps over two years. For survey purposes each installation would have required servicing i.e., reading and statement preparations. This was regarded as an unacceptable time requirement for a theoretical privately sponsored investigation.

Current legislation requires any water utility to provide a water meter at the request of a consumer through the meter-option scheme. This applies equally to domestic and commercial concerns. There are no statutes currently available allowing either enforced meter installation (for domestic consumers) or multi-tariff charging schemes for any consumer. This situation raises the question of:- How can specific domestic consumers be approached and requested to participate in metering trials?

Experience, gained so far, indicates that a voluntary approach is required. Ex-gratia payments are offered to attract participants. Short comings of this method are that consumers retain the choice of reverting to rateable value related payment, if unhappy about volumetric charges. The result from an investigative viewpoint is the lack of incentive to consumers to make "water-savings". This reflects in total meterage and could significantly affect predictions.

To study tariff related charging schemes i.e., similar to Electricity Boards Economy 7 system, the situation is equally unclear. If a meter is required the points described above apply equally. However my own thoughts are that a set of standards of service could be offered to the consumer. Some of these could operate without a water meter i.e., pressure or flow reduction devices fitted at consumer boundaries.

The situation as described clearly restricts the experimental approach. Two separate measures have however recently been employed, nationally, which may serve as precedents for this and subsequent domestic metering investigations. First, South-West Water Authority have imposed a condition that requires any property intending to garden water to have a water meter fitted. Secondly, a national joint utilities investigation into an Energy-Management-Unit (E.M.U) is currently just getting underway. The purpose of this trial is to develop a remote sensing display and telemetry unit linking at least water and electricity services. As a side issue however, the local electricity councils have indicated that they wish to enforce payment by meter on both electricity and water using participants.

Finally, in this respect, Government plans include extensive national metering investigations. With the realization that enforced metering is outside of current water law, nineteen new powers are being debated for adoption. The creation of these powers would allow investigations to proceed more easily and include the right to compulsorily install a domestic meter and to recover the costs of doing so!

In the event that such powers are not adopted in the near future, I will have to maximise the meter option scheme i.e., domestic consumers choosing to pay by meter on their own behalf. To extend the trial to others as yet un-metered properties I will have to rely upon promised potential "bill" reductions as incentives to attract selected consumers to my proposed metering trials.

Work Context

In theory the philosophy of metering all consumers, and so providing a "pay-as-you-use" mechanism, appears desirable. In practice this holds true for the industrial sector, i.e., the larger users, who are, generally, already metered. In fact this policy is often beneficial and can yield substantial savings when volumetric charges are compared to the rateable value system. For example, high street shops, subject to very high rates, and therefore high water service charges are actually low water users.

For heavier industrial users, metering provides a check on volumes consumed and therefore a real incentive to economise. This is very much the trend with minimum water use devices being installed from bars to breweries: Most "bolt-on" installations provide a pay-back period of one year or less. A typical example is the auto-flush urinal common throughout the country. The fitting of a restrictor reducing flushing frequency from once in 20 minutes to once in say two hours (and even longer outside licensing hours) can save £50/annum for each urinal installation. Many local breweries for example, have investigated proprietary devices and are installing them at each hostlery in anticipation of reduced water service charges.

Further the tremendous variance of both commercial rateable values and amounts of water consumed render a charging system similar to the domestic situation unworkable. Industry would regard the discrimination against high rate payers and low water users as inequitable, therefore metering is, at present, the only acceptable solution.

This system allows the industrial consumer to retain the choice of how much water to use in its commercial process. That is to provide a service or product, including welfare facilities for employees. Water Charges can therefore be legitimately included as an overhead together with all other utility costs.

What then of the domestic group of consumers who form the majority of water serviced properties in the country? i.e.,430,000 out of 450,000 at South Staffs alone. To generalise both domestic rateable value and consumption per dwelling are well below commercial equivalents. Further the limited degree of variation between the highest and lowest of these two measures had allowed traditional domestic water service charges to be levied pro-rata to rateable value.

Before the formation of the U.K. Water Authorities in 1974, charges were included in the general rate demand issued twice yearly to each household. The cost of water services was therefore not obvious to each customer, indeed I know of people who regarded water as a "free" commodity.

Post 1974 a separate account for water supply, sewage and environmental charges has become the norm. "Bill watchers" have seen therefore both the introduction of charges specifically for water and subsequently a steady increase to the point where the average annual bill in South Staffs is £32 for water alone.

Unlike gas, electricity and telephone services the domestic consumer was not able to "influence" water charges according to his particular use. This was therefore interpreted as an inequitable charging mechanism. Public, Political and Water Industry concern over this issue led to the formation of the domestic meter option scheme in the early 1980's. By offering this option, domestic consumers were provided with a "safety valve" through which they could choose to pay according to quantities used rather than rateable value.

To date at South Staffs only 520 domestic consumers have opted to pay by meter. This represents less than 0.15% of the total group. Brief analysis of domestic meter option statistics reveals that although these 520 consumers are amongst the highest rated households they also consume well above average quantities of water. It is likely that a further 10,000 domestic consumers would derive benefits, under present charging policies, by electing to pay by meter. Why then do they not opt for this scheme?

A section of my research will be devoted to investigating this question. However it seems likely that domestic consumers are suspicious of metering and are content to sacrifice at least the potential short-term advantages in favour of the traditional charging system.

Recent political messages are that the Government wishes to sell-off U.K. Water Industry in line with its privatisation policies and secondly that payment, of water services, by meter should be vigorously pursued.**

** Fair Deal for Water
** Government White Paper on Privatisation.

In many quarters it is seen that a policy of universal domestic metering would make water utilities more attractive to prospective purchasers and hence smooth privatisation. However does this opinion hold true? If water service charges could be set without re-course to political pressure and competition between utilities for lowest prices was subject to a price setting cartel charges even under the existing system could be levied to yield vast profits. Surely this is an attractive suggestion and avoids the potential headaches concerned with meter provision, installation and servicing.

A particular advantage of metering is the introduction of varying tariff charges. This method would allow the enforcement of time-of-day or quantity tariffs. These could be used by water utilities to load consumers charges. Benefits to the customer are potential cost savings, according to his section of standards of supply. Advantages to the utility by engineering the pricing structure are, theoritically, as follows:

i) A reduction of "peak" demand by spreading loads over longer periods i.e., night time garden watering. Further the charge penalties of exceeding set tariff structures would be designed to finance additional resources to meet the consequent peaks.

ii) It is a reasonable assumption that "average" volumetric charges would initially be fixed to coincide with existing "average" rateable value charges. By artifically lowering the tariff horizons a mechanism to generate above "average" revenue income could be introduced. This would clearly create larger profits and would be "hidden" to the consumer, i.e., difficult to detect subtle alterations in pricing structure. This represents the back-door approach to profits through imposed metering that may be most attractive to the privatisation philosophy. It is to be hoped that such a scenario could be avoided through the honesty and professionalism of water utilities, the intervention of political and private "watch-dogs" and the introduction of competition within the U.K.

In the present political climate it appears that universal domestic metering will be pursued. I propose to investigate the implications that adoption of such a policy would impose. As a full time employee of South Staffordshire Waterworks

Company my research must, principally, be designed to yield long-term benefits to the Company. However the wider implications to the U.K. Water Industry and, as a public service industry, the knock-on effects to the water using public will also be considered.

As already described only a fraction of domestic water consumers are metered. These tend to fall into the higher socio-economic categories. As a result, detailed knowledge of metering, for example terraced housing, is not available. If universal metering were introduced it would affect all categories of housing stock. Part of my experimental work will therefore be directed to household types outside of the meter options character. At this stage I intend to approach consumers through questionnaires to determine attitudes and, where possible, through the installation of meters to confirm habits and test reactions. It must be borne in mind that metering costs money and this is obviously limited (see practical constraints).

The Department of the Environments Joint Study Report into Water Metering* investigated many aspects of domestic consumption. (See literature survey and issues arising). This report indicated that the cost-effectiveness of universal domestic metering was, at best, marginal. It was considered that if meters were, in fact, situated at property boundary**, because of increased installation costs universal metering would in general not be economic.

If however meters continue to be located at the rising main, i.e., inside each property, the responsibility for the communication pipe** presumably becomes the water utilities. I intend to investigate this grey area to determine the extensive implications especially at South Staffs.

As mentioned in the previous section, Practical Constraints, national E.M.U. trials are commencing within the U.K. South Staffs were involved but declined to continue partially because of government unwillingness to assist towards trial costs. The reasons behind this withdrawal are indicted in my letter to the Water Research Centre of April, 1986 a copy of which is included at the rear of this section. Company philosophy is therefore that metering suggestions are principally for the benefit of Government, through proposed privatisation, and that Government ought to offer assistance for, especially, private water undertakings to co-operate. This obviously has an

* Watts, Report
** Water Act

effect upon my own proposed investigations and is one of the principle reasons behind my revised, and cheaper, experimental programme.

The Company, although directly answerable to its shareholders must, as with all businesses, place the consumer first. In a monopoly situation such as the water industry customers are even more important:- they have no choice but to pay water rates to the utility and must therefore receive some protection.

The principle staff representative union N.A.L.G.O. do not regard water as a commodity to be bought and sold. Instead they suggest it should, in effect, be treated as part of the nations public heath service. Unlike gas or electricity the supply of water is not, in any way, optional to the consumer. It is argued that the largest percentage of a water utilities cost relates to the provision and maintenance of hardware. The difference in costs of water supplied to individual consumers is therefore insignificant.

Whilst theoretically agreeing with this point of view I propose to carry out my research on the following grounds.

1. Other utilities are subject to similar hardware costs and operate successful metering schemes. The Water Industry is out of step and it would appear that costs of water supplied are not necessarily insignificant nor is the provision of hardware constant for each consumer.

2. If a domestic metering scheme is to be imposed, the water Industry would benefit from experience of system operation gained during investigations.

3. Many consumers could stand to benefit from the provision of metering and/or selection of a standard of service.

Finally, although "metering" is the mechanism most likely to be adopted as a charging system my research is intended to investigate alternatives. These could have the advantages of much lower installation and running costs, than metering, with consequent savings passed to the consumer. Principle suggestions are flow or pressure reduction devices placed at consumer boundaries.

A number of proprietary devices are now available to facilitate boundary metering. Amongst the many advantages that these offer are the ease of retrofitting water meters and the ability to accept flow-restrictors. Principal among these devices is the "Water Box". I am involved in assessing performance as part of my normal professional activities. Where possible I intend to link my research of influencing devices to assessment of "water boxes" and hence derive a two-fold benefit.

The choice to the consumer requires an active decision to select specific standards of service. does he want 15 or 20 metres pressure head or 8, 10 or 15 litres of water per minute to be available. Once the choice is made and equipment installed the consumer is secure in the knowledge that he gets what he is paying for and the utility operates with the knowledge that the service standard, which may be lower or higher than previously in force, is being paid for. A general selection of lower standards of service would require lower supply requirements in that area and particularly a reduction in peak demand. In contrast, payment by meter allows no specific local targets to be met. Rather resources must always be available to meet peak demand. This of course applies even to consumers electing to pay by tariff controlled standards of service i.e., no active decision is required by the consumer to pre-determine his upper limit of consumption. It is however considered that localised peaks would, under the metering tariff system, be lower than previous uncontrolled regimes.

Who pays for standard of service influencing devices? Should they be treated like water meters and the consumer pay? Or should the utility pay? This question along with the many other difficulties posed by this system will be treated in my research within the South Staffs Area.

P. A. Capener
July, 1986

4. Revised Aims and Hypothesis

Revised Aims

(1) To investigate the effects on domestic water consumption of fiscal, physical and voluntary "influencing" measures.

(2) To analyse the effects of (i) on peak supply demands of utility.

(3) To analyse the effects of (i) on existing revenue systems.

(4) To investigate suitable alterations to revenue charging systems including tariff and billing measures.

Revised Hypothesis

(1) That projected domestic demand patterns will cause supply shortages in the near future at present resource levels.

(2) That metering domestic supplies without pricing does not have a significant effect on demand patterns.

(3) That pricing by metering can have a sufficient effect on demand patterns to forestall significant capital expenditure, at price levels which do not differ substantially from present average costs to households.

(4) That the effect of metering on demand patterns differs substantially between household types.

(5) That restrictions on domestic supplies can have a sufficient effect on demand patterns to forestall significant capital expenditure.

(6) That restrictions have a greater effect on domestic demand patterns for some uses than for others.

(7) That the effect of restrictions on domestic demand patterns does not vary significantly by household type.

APPENDIX B

DETAILS OF 'MODERATOR' PERFORMANCE TESTS

Unrestricted manifold trials showed the following results:-

1 to 2$^{1}/_{2}$ Bar inlet pressure - 30 L/M

4 Bar " - 35 L/M

Flow then gradually increased up to 40 L/M at 10 Bar pressure.

Fitting the respective Top Hat valves into the manifold gave the following:-

Flow Rate	15 L/M	20 L/M	25 L/M	28 L/M
Inlet Prss.				
1 Bar	14	18.5		26.5
1.5	14	19		27
2	15	20		27.5
3	15	20.5		28
4	15	20		28
5	15.5	21	25	29
6	16	20	26	29
7	15.5	20	27	30
8	16	21	25	29
9	15	21	25	28
10	15	20	25	28

These tests have been carried out over a long run period.

Each valve has been running for a 24 hour period at each pressure level, to allow for any fluctuations. The valve was then subject to rapid increase and decrease of pressure, over the 1 - 10 Bar range, to check variation of flow.

SOUTH STAFFORDSHIRE WATERWORKS COMPANY

METERED CONSUMERS:- QUESTIONNAIRE

1) Name of Company/House Owner: ....

2) Site Use: ....

3) Years on this site: .... 3a) Metered Category: ....

4) Site Address: ....

....

....

5) Name of Interviewee: .... 6) Position: ....

	1980	81	82	83	84	85	86	87	88
7) Turnover of Company (at this site):									
8) Profits from this site:									
9) Nr of equivalent full time employees:									
10) Nr of meters feeding site a) Interviewee:									
b) SSWWCo:									
11) Consumption history a) Interviewee:									
b) SSWWCo:									

12) Remarks ie: details of usage (washing, production) night/shift work, storage etc:
....

....

13) a) What is your current water bill?: ....

b) Actual value form SSWWCo records: ....

c) Is bill regarded as high?: ....YES/NO

14) Are any measures proposed or already inforce to reduce consumption?: YES/NO

15) If yes, which of these measures have been considered?

	In-force (since when)	Proposed
a) Re-cycling water		
b) Water economy devices (low flush w.c.'s)		
c) Regular monitoring		
d) Water economic plant		
e) Others (Please specifiy)		

....

16) When was the last voluntary appeal made to reduce your consumption?:

....

17) How did you respond to the appeal?:

Did you a) decrease consumption YES/NO

if yes by how much? 0-5%
5-10%
10-20%
20-30%
>30%

b) ignore the appeal YES/NO

c) take any other action YES/NO

if yes by what?: ....

....

18) Would you respond to a future voluntary appeal?: ....YES/NO

19) Which of the following savings in your annual water bill would stimulate you to adopt (further) "conservation" measures?:

a 0 to 5%
b 5 to 10%
c 10 to 20%
d 20 to 30%
e 30 to 40%
f >40%

OPS/LCU/PAC MAY 1988

20) What price increase over and above inflation would stimulate you to adopt (further) conservation measures?:

a 0 to 5%
b 5 to 10%
c 10 to 20%
d 20 to 30%
e 30 to 40%
f >40%

21) Have you ever been subject to unsatisfactory pressures?: .....YES/NO.

22) Which of the following reductions in pressure could your site withstand?:

a 0 to 5%
b 5 to 10%
c 10 to 15%
d 15 to 20%
e 20 to 30%
f >30%

23) Average supply pressure: ....(SSWCo Records).

TEXT BOUND INTO

THE SPINE

Please Return to:

SOUTH STAFFORDSHIRE WATER COMPANY
GREEN LANE, WALSALL, WS2 7PD.

SOUTH STAFFORDSHIRE WATERWORKS COMPANY
METER CONSUMERS: QUESTIONNAIRE

1) Name of Company/House Owner: ....

2) Site Address: ....
....
....

3) Site Use: ....

4) Measure of Annual Output: ....
(ie. tonnes of steel,
no of pupils, no of
beds, gallons of beer)

5) Years on Site: .... 0 to 1 Yr. ☐ ..a.
1 to 10 Yr. ☐ ..b.
Over 10 Yr. ☐ ..c.

6) Name/Position of Interviewee: ....

7) Tick the different kinds of water usage relevant to you:

Cooling .... ☐ ..a.
Washing .... ☐ ..b.
Process .... ☐ ..c.
Storage .... ☐ ..d.
Domestic .... ☐ ..e.
Environmental .... ☐ ..f.
Other .... ☐ ..g.

If other give details: ....

8) Are your patterns of usage altered by: .... Season.......... ☐ ..a.
Night/day ..... ☐ ..b.
Shiftwork ..... ☐ ..c.
Others .... ☐ ..d.

If other give details: ....

Do you know your current water bill? ....Known......☐..a.

Unknown....☐..b.

Actual value from SSWW is £ ....per year.(to be completed by SSWW)

Is the above bill regarded as ....High......☐..a.

Acceptable.☐..b.

Low........☐..c.

Of all the measures listed below which have you, or would you be most likely to implement to reduce SSWW consumption?

	Done	Proposed	
Nothing......................	☐	☐	a.
Recycling Water..............	☐	☐	b.
Water Economy Devices........	☐	☐	c.
Regular Monitoring...........	☐	☐	d.
Water Economic Plant.........	☐	☐	e.
Alternative Sources..........	☐	☐	f.
Others (Specify).............	☐	☐	g.

....

Do you know when the last voluntary appeal was made to reduce your consumption?

Yes..............☐..a.

No...............☐..b.

If an appeal was made; by how much would you decrease your consumption?

0%................☐..a.

1 to 5%................☐..b.

5 to 10%................☐..c.

10 to 20%................☐..d.

Over 20%................☐..e.

What price increases over and above inflation would stimulate you to adopt (further) conservation measures?

0 to 5%..............☐..a.

5 to 10%..............☐..b.

10 to 15%..............☐..c.

15 to 20%..............☐..d.

Over 20%..............☐..e.

15) Have you ever been subject to unsatisfactory pressures?

Yes............... ☐ ..a.

No............... ☐ ..b.

16) Which of the following reductions in pressure could your site withstand?

0%............... ☐ ..a.

1 to 5%............... ☐ ..b.

5 to 10%............... ☐ ..c.

10 to 20%............... ☐ ..d.

Over 20%............... ☐ ..e.

17) For the purposes of comparison would you indicate your organisations current turnover.

£0 to 1/2m............... ☐ ..a.

1/2 to 1m............... ☐ ..b.

1 to 5m............... ☐ ..c.

5 to 10m............... ☐ ..d.

Over 10m............... ☐ ..e.

18) Has the turnover of the company increased/decreased over the last 10 years, if so by how much?

	DEC	INC	
0 to 5%.....	☐	☐	..a.
5 to 10%.....	☐	☐	..b.
10 to 15%.....	☐	☐	..c.
15 to 20%.....	☐	☐	..d.
Over 20%.....	☐	☐	..e.

19) Your present number of employees is...................

20) Has the number of employees increased/decreased over the last 10 years, if so by how much?

	DEC	INC	
0 to 10%.....	☐	☐	..a.
10 to 20%.....	☐	☐	..b.
20 to 30%.....	☐	☐	..c.
30 to 50%.....	☐	☐	..d.
Over 50%.....	☐	☐	..e.

R1) What energy sources do you use?

Electricity...........................☐..a.
Gas...................................☐..b.
Coal..................................☐..c.
Oil...................................☐..d.
Water.................................☐..e.

R2) Please show each individual energy source as a percentage cost of the total energy bill?

Electricity..............................%.
Gas......................................%.
Coal.....................................%.
Oil......................................%.
Water....................................%.

R3) Please give brief details of any proposals likely to significantly affect SSWW Co consumption in the future?

....
....
....
....
....
....

Thank you for your co-operation.

NOVEMBER

Please Return to:

South Staffs Water Company
Green Lane
Walsall WS2 7PD

Please indicate choices with a tick in the appropriate box or boxes.

METER CONSUMERS QUESTIONAIRE

1. Name of Business/Owner ....
....
....

2. Address..
....
....
....

3. Contact Name.. Telephone No.................................

4. Site Category

   Domestic ☐
   Commercial ☐

5. If Commercial please indicate the relevant type of usage applicable to you

   Cooling ☐
   Storage ☐
   Process ☐
   Domestic ☐
   Other ☐

   If other please give brief details..

6. What is your current Water Bill? ....

7. Do you regard your Water Bill as:-

   High ☐
   Acceptable ☐
   Low ☐

8. If applicable, which of the measures listed below would you most likely implement to reduce water consumption?

- Recycling Water ☐
- Water Economy Devices ☐
- Regular Monitoring ☐
- Others ☐

If others please give brief details..

9. Do you know when the last voluntary appeal was made by SSWW to reduce your water consumption?

- Yes ☐
- No ☐

10. If an appeal was made by SSWW by how much would you reduce your consumption

%

- 0 ☐
- 1–5 ☐
- 5–10 ☐
- 10–20 ☐
- Over 20 ☐

11. Have you ever been subject to unsatisfactory pressure?

- Yes ☐
- No ☐

12. Which of the following reductions in pressure could your premises withstand?

%

- 0 ☐
- 1–5 ☐
- 5–10 ☐
- 10–20 ☐
- Over 20 ☐

13. How many people live or work at this property?....................................

14. If applicable, give details of any future plans for your business or premises that may increase or decrease your water consumption.

....

....

....

....

....

Thank you for your cooperation.

SAMPLE OF "MAJOR METERED CUSTOMERS"

SUMMARY DATA FROM QUESTIONNAIRE

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	category	output	UNITS	YR 5	WATER USAGE ON SITE a cool	b wash	c proc	d stor	e dom	f envi	g othr	h othr
1	A	20000	T/YR	3	1	1	0	1	1	0	0	0
2	A	10000	T/YR	3	0	1	1	1	1	0	0	0
3	A	10000	T/YR	3	1	1	0	1	1	0	0	0
4	A	6000	T/YR	3	1	1	0	1	1	0	0	0
5	B	1800	T/YR	2	1	1	1	1	1	0	0	0
6	B	12000	T/YR	3	1	1	1	1	1	0	0	0
7	B	5000	T/YR	3	1	0	1	1	1	0	0	0
8	B	40000	T/YR	3	1	1	0	1	1	0	0	0
9	C	8000	T/YR	3	1	0	0	1	1	0	0	0
10	C	23000	T/YR	3	1	1	0	1	1	0	0	0
11	C	60000	T/YR	3	1	0	0	1	1	0	0	0
12	D	60000	BARR/YR	3	1	1	1	1	1	0	0	0
13	E	20000	T/YR	3	1	1	1	1	1	0	0	0
14	E	?	?	3	1	1	1	1	1	0	0	0
15	G	300000	T/YR	3	0	1	1	1	1	0	1	0
16	G	?	?	3	0	0	0	1	1	0	0	0
17	B	9000	T/YR	3	0	1	1	1	1	0	0	0
18	C	?	?	3	1	1	0	1	1	0	0	0
19	6	400	BEDS	2	1	1	0	1	1	0	0	0
20	C	1500	T/YR	3	0	1	0	1	1	0	0	0
21	A	4000	T/YR	3	1	1	1	1	1	0	0	0
22	B	?	?	3	1	1	1	1	1	0	0	0
23	B	?	?	3	1	0	1	1	1	0	0	0
24	6	407	BEDS	3	0	0	0	1	1	0	0	0
25	A	9000	T/YR	3	1	1	1	1	1	1	0	0
26	H	182	INMATES	3	0	0	0	1	1	0	0	0
27	H	?	?	3	0	1	0	1	1	0	0	0
28	C	80000	T/YR	3	1	1	1	1	1	0	0	0
29	C	23000	T/YR	3	1	1	1	1	1	1	0	0
30	H	3000000	MILL ITEMS	3	0	1	0	1	1	0	0	0
31	6	350	BEDS	3	0	1	1	1	1	0	0	0
32	6	500	BEDS	3	1	0	0	1	1	0	0	0
33	5	496	BEDS	3	0	0	0	1	1	0	0	0
34	6	350	BEDS	3	0	0	0	1	1	0	0	0
35	6	638	BEDS	3	0	1	0	1	1	0	0	0
36	B	13000	T/YR	3	1	1	1	1	1	0	0	0
37	B	?	?	3	1	1	1	1	1	0	0	0
38	D	350000	BARR/YR	3	1	1	0	1	1	0	0	0
39	G	240000	T/YR	3	0	0	1	1	1	1	0	0
40	F	55000	GALL/YR	2	0	0	0	1	1	0	0	0
41	A	1000000	FASTNERS	3	1	1	0	1	1	0	0	0
42	C	4000	T/YR	3	0	0	1	1	1	0	0	0
43	H	3000000	ITEMS	3	1	1	1	1	1	0	0	0
44	H	?	?	3	0	0	0	1	1	0	1	0
45	3	20000	T/YR	3	1	1	1	1	1	1	0	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	category	output	UNITS	YR 5	WATER USAGE ON SITE a cool	= b wash	= c proc	7 d stor	= e dom	= f envio	= g thr	h othr
46	F	7903	T/YR	3	1	0	1	1	1	0	1	0
47	F	3120000	GALL/YR	2	0	0	1	1	1	0	0	0
48	A	?	?	3	1	0	0	1	1	0	0	0
49	A	?	?	3	1	1	0	1	1	0	0	0
50	B	?	?	3	0	1	1	1	1	0	0	0
51	C	900	T/YR	3	0	0	0	1	1	0	0	0
52	C	300000	T/YR	3	1	0	0	1	1	0	0	0
53	D	2000000	BARR/YR	3	0	1	1	1	1	0	0	0
54	A	15000	T/YR	3	0	1	0	1	1	0	0	0
55	C	11000	T/YR	3	1	1	0	1	1	0	0	0
56	E	150000	T/YR	3	1	0	1	1	1	0	0	0
57	B	?	?	3	0	0	0	1	1	0	0	0
58	A	?	?	2	0	1	0	1	1	0	0	0
59	A	15000	T/YR	3	1	1	1	1	1	0	0	0
60	G	320000	T/YR	3	1	0	1	1	1	0	0	0
61	E	?	?	3	0	0	1	1	1	0	0	0
62	F	30000000	GALL/YR	3	0	1	1	1	1	0	0	0
63	F	?	?	3	0	1	0	1	1	0	0	0
64	F	600000	GALL/YR	3	0	1	1	1	1	0	0	0
65	F	?	?	3	0	1	0	1	1	0	0	0
66	H	?	?	2	0	1	0	1	1	0	0	0
67	I	?	?	3	1	0	0	1	1	0	1	0
68	A	?	?	3	0	1	0	1	1	0	0	0
69	A	?	?	3	0	0	0	1	1	0	0	0
70	A	?	?	3	1	0	1	1	1	0	0	0
71	B	20000	ITEMS	3	0	1	0	1	1	0	0	0
72	B	?	?	3	0	0	0	1	1	0	0	0
73	A	?	?	3	0	1	0	1	1	0	0	0
74	E	15000	T/YR	3	1	1	1	1	1	0	0	0
75	H	?	?	3	0	0	0	1	1	0	0	0
76	H	?	?	3	0	1	0	1	1	0	0	0
77	A	?	?	3	1	1	1	1	1	0	0	0
78	A	1440	T/YR	3	0	0	1	1	1	0	0	0
79	C	?	?	3	1	1	1	1	1	0	0	0
80	D	30000	BARR/YR	3	0	0	1	1	1	0	0	0
81	A	10000	T/YR	3	1	1	1	1	1	1	0	0
82	E	80000	T/YR	3	1	1	1	1	1	0	0	0
83	C	120000	T/YR	3	0	1	0	1	1	0	0	0
84	B	180000	ITEMS	3	1	1	0	1	1	0	0	0
85	A	?	?	3	1	1	1	1	1	0	0	0
86	A	10000	T/YR	3	1	1	0	1	1	0	0	0
87	A	?	?	3	0	0	1	1	1	0	0	0
88	A	1000	T/YR	3	1	1	0	1	1	0	0	0
89	A	?	?	2	0	0	0	1	1	0	0	0
90	C	?	?	3	0	1	0	1	1	0	0	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	cat	USE PATTERN 8 a sea	b cont	c shif	d othr	E? 9 know	REGA 10 reg	m3/yr SSWW Ml	CONSERVATION MEASURE 11 b rec	c eco	d mon	e pla	f altW	g oth
1	A	0	1	0	0	0	1	45	0	1	1	0	0	0
2	A	0	0	0	0	1	2	130	1	1	1	0	0	0
3	A	0	1	0	0	0	2	217	1	1	1	0	0	0
4	A	0	0	1	0	1	1	51	1	0	1	0	0	0
5	B	0	1	0	1	1	2	113	1	1	1	0	0	0
6	B	0	1	0	1	1	2	36	1	0	1	0	0	0
7	B	0	0	1	0	1	1	110	1	0	1	0	0	0
8	B	0	0	1	0	1	2	257	1	1	1	0	0	0
9	C	0	1	0	0	1	2	82	1	0	1	0	0	0
10	C	0	0	1	0	1	2	80	1	0	1	0	0	0
11	C	0	0	0	0	1	3	28	1	0	1	0	0	0
12	D	1	0	1	0	1	2	30	1	1	1	0	0	0
13	E	1	0	0	1	1	1	51	1	0	0	0	0	0
14	E	0	0	0	0	1	1	144	1	1	1	0	0	0
15	G	0	1	0	0	1	2	27	1	1	1	0	1	0
16	G	0	1	0	0	1	2	90	0	0	1	0	0	0
17	B	0	0	0	0	1	1	22	0	0	0	0	0	0
18	C	0	1	0	0	1	3	72	1	0	1	0	0	0
19	6	0	1	0	0	1	1	153	0	1	1	1	0	0
20	C	0	1	0	0	1	3	2	1	1	1	0	0	0
21	A	0	0	1	0	1	1	80	1	1	1	0	0	0
22	B	0	1	0	0	1	2	78	1	1	1	0	0	0
23	B	1	0	0	0	1	1	135	1	1	1	1	1	0
24	6	0	1	0	0	1	2	23	0	1	1	0	0	0
25	A	1	0	1	0	1	1	12	1	1	1	0	0	0
26	H	0	1	0	0	1	1	22	0	0	1	0	0	0
27	H	0	1	0	0	1	2	65	0	0	0	0	0	0
28	C	0	1	0	0	1	2	23	1	0	1	0	0	0
29	C	0	1	0	0	1	2	15	1	1	1	0	0	0
30	H	1	0	0	0	1	2	22	0	1	0	0	0	0
31	6	0	1	0	0	1	2	38	1	1	1	0	0	0
32	6	0	1	0	0	0	2	100	1	1	1	0	0	0
33	6	0	1	0	0	1	2	113	1	1	1	0	0	0
34	6	0	0	1	0	1	2	6	1	1	1	0	0	0
35	6	0	1	0	0	1	2	80	0	0	1	0	0	0
36	B	0	0	0	0	1	1	21	0	0	0	0	0	0
37	B	0	0	0	0	0	2	42	1	1	1	0	0	0
38	D	0	1	0	0	1	2	113	1	1	1	1	0	0
39	G	0	1	0	0	0	2	67	0	0	1	0	0	0
40	F	0	0	0	0	0	2	1	0	1	1	0	0	0
41	A	0	0	0	0	1	1	157	1	1	1	0	0	0
42	C	0	1	0	0	0	2	17	0	1	1	0	0	0
43	H	1	1	0	0	1	1	26	0	1	1	1	0	0
44	H	1	0	0	0	0	2	15	0	1	0	0	1	0
45	B	0	1	0	0	1	1	73	0	0	0	0	0	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref		USE PATTERN				b?	REGAm3/yr	CONSERVATION MEASURE					
		8				9	10	SSWW	11				
	cat	a	b	c	d				b	c	d	e	f	g
		sea	cont	shif	othr	know	reg	Ml	rec	eco	mon	plan	altW	oth
46	F	0	1	0	0	1	1	306	1	0	1	0	0	0
47	F	0	0	1	0	1	2	47	0	0	1	1	0	0
48	A	0	0	0	0	0	2	20	1	0	0	1	0	0
49	A	0	0	0	0	1	1	63	1	1	1	0	0	0
50	B	0	1	0	0	0	2	22	0	0	0	1	0	0
51	C	0	0	0	0	1	2	28	1	0	1	0	0	0
52	C	0	0	0	0	0	2	111	1	0	1	0	0	0
53	D	0	0	0	0	1	1	409	1	1	1	0	0	0
54	A	0	0	0	0	1	2	99	1	0	1	0	0	0
55	C	0	0	0	0	0	2	72	1	1	1	0	0	0
56	E	0	0	0	0	1	2	627	1	1	1	1	0	0
57	B	0	1	0	0	1	1	101	1	0	1	0	0	0
58	A	0	1	0	0	1	1	82	0	0	1	0	0	0
59	A	0	0	1	0	1	1	52	0	0	0	0	0	0
60	G	0	0	0	0	0	2	28	0	0	0	0	0	0
61	E	0	0	1	0	1	1	219	1	0	1	1	0	0
62	F	0	0	1	0	1	2	358	0	1	1	0	0	0
63	F	1	0	1	0	0	2	336	1	1	1	1	0	0
64	F	1	0	1	0	1	2	103	0	0	1	1	0	0
65	F	1	1	0	0	1	1	43	0	1	1	0	0	0
66	H	0	0	0	0	0	1	66	0	0	1	1	0	0
67	1	0	1	0	0	1	1	443	0	0	1	1	1	0
68	A	0	0	0	0	0	1	61	1	1	1	0	0	1
69	A	0	0	0	0	0	1	34	1	1	1	0	0	0
70	A	0	1	0	0	1	3	97	1	1	1	0	0	0
71	B	0	0	0	0	1	1	40	1	1	0	0	0	0
72	B	0	1	0	0	1	1	62	1	1	1	0	0	0
73	A	0	1	0	0	0	1	47	1	1	1	0	1	0
74	E	0	0	0	0	1	2	1	0	0	1	0	0	0
75	H	0	0	0	0	1	2	1	0	0	0	0	0	0
76	H	0	0	0	0	0	2	1	0	0	0	0	0	0
77	A	1	1	0	0	1	1	60	1	1	1	0	0	0
78	A	0	1	0	0	1	1	8	0	0	1	0	0	0
79	C	0	1	0	0	1	1	7	0	1	0	0	0	0
80	D	0	0	0	1	1	1	2	1	0	1	0	1	0
81	A	1	0	0	0	1	1	35	0	0	0	0	0	0
82	E	0	1	0	0	1	1	200	1	0	1	0	0	0
83	C	0	0	0	0	1	2	4	0	1	1	0	0	0
84	B	1	1	0	0	1	2	11	1	0	1	1	0	0
85	A	0	0	0	0	1	1	10	1	1	1	0	0	0
86	A	0	0	1	0	1	2	4	1	0	1	0	0	0
87	A	0	1	0	0	1	1	60	0	0	1	0	0	0
88	A	0	0	0	0	0	2	8	1	0	1	0	0	0
89	A	0	0	0	0	1	1	12	0	0	0	0	0	0
90	C	0	0	0	0	0	1	144	1	0	1	0	1	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	categor	Y?N 12 appl	CONSERVATION POTENTI 13 a 0	b <5%	c <10%	d <20%	e >20%	PRICE SENSITIVITY 14 a E0%	b E<10%	c E<15%	d E<20%	e E>20%
1	A	0	0	0	0	1	0	0	1	0	0	0
2	A	0	0	1	0	0	0	1	0	0	0	0
3	A	0	0	0	1	0	0	0	1	0	0	0
4	A	1	0	1	0	0	0	1	0	0	0	0
5	B	0	1	0	0	0	0	1	0	0	0	0
6	B	0	0	1	0	0	0	1	0	0	0	0
7	B	0	1	0	0	0	0	1	0	0	0	0
8	B	0	0	1	0	0	0	1	0	0	0	0
9	C	0	1	0	0	0	0	1	0	0	0	0
10	C	0	0	0	1	0	0	1	0	0	0	0
11	C	0	0	1	0	0	0	1	0	0	0	0
12	D	0	1	0	0	0	0	0	0	1	0	0
13	E	0	0	1	0	0	0	1	0	0	0	0
14	E	0	1	0	0	0	0	1	0	0	0	0
15	G	0	1	0	0	0	0	1	0	0	0	0
16	G	0	1	0	0	0	0	1	0	0	0	0
17	B	0	1	0	0	0	0	1	0	0	0	0
18	C	0	0	1	0	0	0	1	0	0	0	0
19	6	1	0	1	0	0	0	0	0	0	0	1
20	C	0	0	1	0	0	0	1	0	0	0	0
21	A	0	0	1	0	0	0	1	0	0	0	0
22	B	0	0	1	0	0	0	1	0	0	0	0
23	3	0	0	1	0	0	0	1	0	0	0	0
24	6	1	0	0	0	0	1	1	0	0	0	0
25	A	0	1	0	0	0	0	1	0	0	0	0
26	H	0	1	0	0	0	0	1	0	0	0	0
27	H	0	1	0	0	0	0	0	1	0	0	0
28	C	0	0	1	0	0	0	1	0	0	0	0
29	C	1	1	0	0	0	0	1	0	0	0	0
30	H	1	1	0	0	0	0	0	0	0	1	0
31	6	0	0	1	0	0	0	1	0	0	0	0
32	6	0	0	1	0	0	0	0	1	0	0	0
33	6	1	0	0	1	0	0	1	0	0	0	0
34	6	1	0	1	0	0	0	1	0	0	0	0
35	6	0	0	1	0	0	0	0	0	1	0	0
36	B	1	0	1	0	0	0	1	0	0	0	0
37	B	0	0	1	0	0	0	1	0	0	0	0
38	D	1	0	1	0	0	0	0	1	0	0	0
39	G	0	1	0	0	0	0	1	0	0	0	0
40	F	0	0	0	1	0	0	1	0	0	0	0
41	A	1	0	0	1	0	0	1	0	0	0	0
42	C	0	0	0	1	0	0	0	1	0	0	0
43	H	0	0	1	0	0	0	0	1	0	0	0
44	H	0	1	0	0	0	0	0	1	0	0	0
45	3	0	0	1	0	0	0	1	0	0	0	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	categor	Y?N 12 appl	CONSERVATION POTENTI 13 a 0	b <5%	c <10%	d <20%	e >20%	PRICE SENSITIVITY 14 a ≤0%	b ≤<10%	c ≤<15%	d ≤<20%	e ≤>20%
46	F	1	0	0	0	0	1	1	0	0	0	0
47	F	0	0	1	0	0	0	0	1	0	0	0
48	A	0	0	1	0	0	0	1	0	0	0	0
49	A	1	0	0	0	0	1	1	0	0	0	0
50	B	1	0	0	0	0	1	0	0	0	1	0
51	C	1	0	0	1	0	0	1	0	0	0	0
52	C	1	0	1	0	0	0	1	0	0	0	0
53	D	0	0	0	1	0	0	0	0	0	1	0
54	A	1	0	0	1	0	0	0	1	0	0	0
55	C	0	0	1	0	0	0	1	0	0	0	0
56	E	1	0	1	0	0	0	1	0	0	0	0
57	B	0	0	1	0	0	0	1	0	0	0	0
58	A	0	1	0	0	0	0	1	0	0	0	0
59	A	0	1	0	0	0	0	1	0	0	0	0
60	G	0	1	0	0	0	0	1	0	0	0	0
61	E	1	0	1	0	0	0	1	0	0	0	0
62	F	0	0	1	0	0	0	1	0	0	0	0
63	F	0	0	1	0	0	0	1	0	0	0	0
64	F	0	0	1	0	0	0	0	0	0	0	1
65	F	0	0	0	1	0	0	1	0	0	0	0
66	H	0	0	0	1	0	0	1	0	0	0	0
67	I	1	0	0	0	1	0	0	1	0	0	0
68	A	1	0	0	1	0	0	0	1	0	0	0
69	A	1	0	1	0	0	0	1	0	0	0	0
70	A	1	0	1	0	0	0	1	0	0	0	0
71	B	0	0	1	0	0	0	0	0	0	1	0
72	B	0	0	0	0	1	0	1	0	0	0	0
73	A	0	0	0	0	0	1	0	0	0	0	1
74	E	0	1	0	0	0	0	0	1	0	0	0
75	H	0	0	0	0	0	1	0	1	0	0	0
76	H	0	1	0	0	0	0	0	1	0	0	0
77	A	0	0	1	0	0	0	1	0	0	0	0
78	A	0	1	0	0	0	0	1	0	0	0	0
79	C	0	0	1	0	0	0	0	1	0	0	0
80	D	0	1	0	0	0	0	1	0	0	0	0
81	A	0	0	0	1	0	0	0	1	0	0	0
82	E	0	1	0	0	0	0	1	0	0	0	0
83	C	0	1	0	0	0	0	0	1	0	0	0
84	B	1	0	1	0	0	0	0	1	0	0	0
85	A	0	1	0	0	0	0	1	0	0	0	0
86	A	0	1	0	0	0	0	0	1	0	0	0
87	A	0	0	1	0	0	0	0	0	0	1	0
88	A	0	0	1	0	0	0	0	0	1	0	0
89	A	0	1	0	0	0	0	0	1	0	0	0
90	C	1	0	0	0	1	0	1	0	0	0	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	PRE 15 categor	P?	PRESSURE REDUCTIONS 16 a p0%	b p<5%	c p<10%	d p<20%	e p>20%	ANNUAL TURNOVER £M 17 a £<0.5	b £<1M	c £<5M	d £<10M	e £>10M
1	A	0	0	0	1	0	0	0	0	1	0	0
2	A	0	0	1	0	0	0	0	0	0	0	1
3	A	0	0	0	1	0	0	0	0	1	0	0
4	A	0	0	0	0	1	0	0	0	0	1	0
5	B	1	0	1	0	0	0	0	0	1	0	0
6	B	0	0	0	1	0	0	0	0	0	0	1
7	B	0	0	1	0	0	0	0	0	1	0	0
8	B	0	0	0	1	0	0	0	0	0	0	1
9	C	0	0	1	0	0	0	0	0	0	0	1
10	C	1	0	0	1	0	0	0	0	0	0	1
11	C	0	0	0	1	0	0	0	0	0	0	1
12	D	0	0	1	0	0	0	0	0	0	0	1
13	E	1	1	0	0	0	0	0	0	0	0	1
14	E	0	0	0	1	0	0	0	0	0	0	1
15	G	0	0	0	1	0	0	0	0	0	0	1
16	G	0	0	1	0	0	0	0	0	0	0	1
17	B	0	0	1	0	0	0	0	1	0	0	0
18	C	1	0	1	0	0	0	0	0	0	0	0
19	G	0	0	0	0	1	0	0	0	0	0	1
20	C	0	0	1	0	0	0	0	0	0	1	0
21	A	1	0	1	0	0	0	0	0	0	0	1
22	B	1	1	0	0	0	0	0	0	0	0	1
23	B	0	0	1	0	0	0	0	0	0	0	1
24	G	1	0	1	0	0	0	0	0	0	0	1
25	A	0	1	0	0	0	0	0	0	0	0	1
26	H	1	1	0	0	0	0	0	0	0	0	1
27	H	0	0	1	0	0	0	0	0	1	0	0
28	C	0	0	1	0	0	0	0	0	0	0	1
29	C	1	1	0	0	0	0	0	0	0	0	1
30	H	1	0	0	1	0	0	0	0	1	0	0
31	G	0	0	0	1	0	0	0	0	0	0	1
32	G	0	0	0	1	0	0	0	0	0	0	1
33	G	1	0	1	0	0	0	0	0	0	0	1
34	G	0	0	0	1	0	0	0	0	0	0	1
35	G	0	0	0	1	0	0	0	0	0	1	0
36	B	1	1	0	0	0	0	0	1	0	0	0
37	B	0	0	1	0	0	0	0	0	0	1	0
38	D	0	0	0	1	0	0	0	0	0	0	1
39	G	0	0	0	1	0	0	1	0	0	0	0
40	F	0	0	0	0	1	0	0	0	0	1	0
41	A	1	0	0	1	0	0	0	0	1	0	0
42	C	0	0	0	1	0	0	0	0	0	0	1
43	H	1	0	0	1	0	0	0	0	0	1	0
44	H	1	0	0	1	0	0	0	0	0	0	1
45	B	0	0	1	0	0	0	0	0	0	0	1

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	PRE 15		PRESSURE REDUCTIONS 16					ANNUAL TURNOVER £M 17				
	categor	P?	a p0%	b p<5%	c p<10%	d p<20%	e p>20%	a £<0.5	b £<1M	c £<5M	d £<10M	e £>10M
46	F	0	0	1	0	0	0	0	0	0	0	1
47	F	1	0	0	0	1	0	0	0	0	1	0
48	A	0	0	1	0	0	0	0	0	0	0	1
49	A	1	0	1	0	0	0	0	0	0	1	0
50	B	0	0	1	0	0	0	0	0	0	0	1
51	C	0	1	0	0	0	0	0	0	0	0	1
52	C	0	0	1	0	0	0	0	0	0	0	1
53	D	0	0	0	1	0	0	0	0	0	0	1
54	A	1	0	0	0	1	0	0	0	0	0	1
55	C	0	0	1	0	0	0	0	0	0	0	1
56	E	1	0	1	0	0	0	0	0	0	0	1
57	B	1	1	0	0	0	0	0	0	0	0	1
58	A	0	0	1	0	0	0	0	0	0	0	1
59	A	0	1	0	0	0	0	0	0	0	0	1
60	G	0	1	0	0	0	0	0	0	0	0	1
61	E	1	0	0	1	0	0	0	0	0	0	1
62	F	0	0	1	0	0	0	0	0	0	0	1
63	F	0	0	1	0	0	0	0	0	0	0	1
64	F	0	0	1	0	0	0	0	0	0	0	1
65	F	0	0	1	0	0	0	0	0	0	1	0
66	H	1	0	1	0	0	0	0	0	1	0	0
67	I	0	0	1	0	0	0	0	0	0	0	1
68	A	0	0	0	1	0	0	0	0	0	0	1
69	A	1	0	1	0	0	0	0	0	1	0	0
70	A	1	0	1	0	0	0	0	0	0	0	1
71	B	0	0	1	0	0	0	0	0	0	0	1
72	B	0	0	0	1	0	0	0	0	0	0	1
73	A	0	0	1	0	0	0	0	0	0	1	0
74	E	1	1	0	0	0	0	0	0	0	0	1
75	H	0	0	0	1	0	0	0	0	0	0	1
76	H	0	0	0	1	0	0	0	0	0	0	1
77	A	0	0	0	1	0	0	0	0	0	0	1
78	A	0	1	0	0	0	0	0	1	0	0	0
79	C	0	1	0	0	0	0	0	0	0	0	1
80	D	0	0	0	0	0	1	1	0	0	0	0
81	A	1	1	0	0	0	0	0	0	0	1	0
82	E	1	1	0	0	0	0	0	0	0	0	1
83	C	0	0	0	1	0	0	0	0	0	0	1
84	B	0	0	1	0	0	0	0	0	0	1	0
85	A	1	1	0	0	0	0	0	1	0	0	0
86	A	0	1	0	0	0	0	0	0	0	0	1
87	A	1	0	0	0	1	0	0	0	0	0	1
88	A	0	0	1	0	0	0	0	0	1	0	0
89	A	0	1	0	0	0	0	0	0	0	0	1
90	C	1	0	1	0	0	0	0	0	0	0	1

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	cat	TURNOVER DEC a	b	c	d	e	INC a	b	c	d	e
		¦	=	=	=	=	18	=	=	=	¦
1	A	0	0	0	0	0	0	0	0	1	0
2	A	0	0	0	1	0	0	0	0	0	0
3	A	0	0	0	0	0	1	0	0	0	0
4	A	0	0	0	0	1	0	0	0	0	0
5	B	1	0	0	0	0	0	0	0	0	0
6	B	0	0	0	0	0	0	0	1	0	0
7	B	0	0	0	0	0	0	1	0	0	0
8	B	0	0	0	0	0	0	0	0	0	1
9	C	1	0	0	0	0	0	0	0	0	0
10	C	0	0	0	0	0	1	0	0	0	0
11	C	0	0	0	0	0	0	1	0	0	0
12	D	0	0	0	0	0	0	0	0	1	0
13	E	0	0	0	0	0	1	0	0	0	0
14	E	0	0	0	0	0	0	0	0	1	0
15	G	0	0	0	0	0	0	0	0	0	1
16	G	0	0	0	0	0	0	0	0	0	0
17	B	0	0	0	1	0	0	0	0	0	0
18	C	0	0	0	0	0	0	0	0	0	0
19	6	0	0	0	0	0	1	0	0	0	0
20	C	0	0	0	0	0	0	0	0	0	1
21	A	0	0	0	0	0	0	0	1	0	0
22	B	0	0	0	0	1	0	0	0	0	0
23	B	0	0	0	0	0	0	1	0	0	0
24	6	0	0	0	0	0	0	0	0	0	1
25	A	0	0	0	0	0	0	0	0	0	1
26	H	0	0	0	0	0	0	1	0	0	0
27	H	0	0	0	0	0	0	0	0	0	1
28	C	0	0	0	0	0	0	0	0	0	1
29	C	0	0	0	0	0	0	0	0	0	1
30	H	0	0	0	0	0	0	0	1	0	0
31	6	0	0	0	0	0	0	0	1	0	0
32	6	0	0	0	0	0	0	0	0	1	0
33	6	0	0	0	0	0	0	0	0	1	0
34	6	0	0	0	0	0	0	0	0	1	0
35	6	0	0	0	0	0	0	1	0	0	0
36	B	1	0	0	0	0	0	0	0	0	0
37	B	0	0	0	0	0	1	0	0	0	0
38	D	0	0	0	0	0	0	0	0	0	1
39	G	0	0	0	0	0	0	0	0	1	0
40	F	0	0	0	0	0	1	0	0	0	0
41	A	0	0	0	0	0	0	0	1	0	0
42	C	0	0	0	0	0	0	0	1	0	0
43	H	0	0	0	0	0	0	0	0	0	1
44	H	0	0	0	0	0	0	0	0	0	1
45	3	0	0	0	0	0	0	0	0	0	1

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref		TURNOVER									
		¦	=	=	=	=	18	=	=	=	¦
	cat	a	b	c	d	e	a	b	c	d	e
		--------DEC					--------INC			--------	
46	F	0	0	0	0	0	1	0	0	0	0
47	F	0	0	0	0	0	0	0	0	0	0
48	A	0	0	0	0	0	0	0	0	0	0
49	A	0	0	0	0	0	0	0	0	0	0
50	B	0	0	0	0	0	0	1	0	0	0
51	C	0	0	0	0	1	0	0	0	0	0
52	C	0	0	0	0	0	0	0	1	0	0
53	D	0	0	0	0	0	0	0	0	0	1
54	A	0	0	0	0	0	1	0	0	0	0
55	C	0	0	0	0	0	0	0	1	0	0
56	E	0	0	0	0	0	0	0	1	0	0
57	B	0	0	0	0	0	0	0	0	0	1
58	A	0	0	0	0	0	0	0	0	0	1
59	A	0	0	0	0	0	0	0	1	0	0
60	G	0	0	0	0	0	0	0	0	1	0
61	E	0	0	0	0	1	0	0	0	0	0
62	F	0	0	0	0	0	0	0	0	0	1
63	F	0	0	0	0	0	0	0	0	0	1
64	F	0	0	0	0	0	1	0	0	0	0
65	F	0	0	0	0	0	1	0	0	0	0
66	H	0	0	0	0	0	0	0	0	0	1
67	I	0	0	0	0	0	0	0	0	0	1
68	A	0	0	0	0	0	0	0	0	0	1
69	A	0	0	0	0	0	0	1	0	0	0
70	A	0	0	0	0	0	0	0	0	0	1
71	B	0	0	0	0	0	0	0	0	0	1
72	B	0	0	0	0	0	0	0	0	0	1
73	A	0	0	0	0	0	0	1	0	0	0
74	E	0	0	0	0	1	0	0	0	0	0
75	H	0	0	0	0	0	0	0	0	0	1
76	H	0	0	0	0	0	0	0	0	0	1
77	A	0	0	0	0	0	0	0	0	0	1
78	A	0	0	0	0	0	0	0	0	0	1
79	C	0	0	0	0	0	0	0	0	0	1
80	D	0	0	0	0	1	0	0	0	0	0
81	A	0	0	0	0	0	1	0	0	0	0
82	E	0	0	0	0	0	1	0	0	0	0
83	C	0	0	0	0	0	0	0	0	0	1
84	B	0	0	0	0	0	0	1	0	0	0
85	A	0	0	0	0	0	0	1	0	0	0
86	A	0	0	0	0	0	1	0	0	0	0
87	A	0	0	0	0	0	1	0	0	0	0
88	A	0	0	0	0	0	0	0	0	1	0
89	A	0	0	0	0	0	0	0	0	0	1
90	C	0	0	0	0	0	0	0	0	1	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref		EMPLOYEES									
		¦	=	=	=	20	=	=	=	=	¦
	cat	a	b	c	d	e	a	b	c	d	e
		-------DEC					--------INC			--------	
1	A	0	1	0	0	0	0	0	0	0	0
2	A	1	0	0	0	0	0	0	0	0	0
3	A	0	1	0	0	0	0	0	0	0	0
4	A	0	0	0	1	0	0	0	0	0	0
5	B	0	0	0	0	0	1	0	0	0	0
6	B	1	0	0	0	0	0	0	0	0	0
7	B	1	0	0	0	0	0	0	0	0	0
8	B	0	0	0	1	0	0	0	0	0	0
9	C	0	1	0	0	0	0	0	0	0	0
10	C	1	0	0	0	0	0	0	0	0	0
11	C	0	0	0	1	0	0	0	0	0	0
12	D	0	0	0	1	0	0	0	0	0	0
13	E	0	0	0	0	0	0	0	0	0	0
14	E	1	0	0	0	0	0	0	0	0	0
15	G	1	0	0	0	0	0	0	0	0	0
16	G	0	0	0	0	0	1	0	0	0	0
17	B	0	0	1	0	0	0	0	0	0	0
18	C	1	0	0	0	0	0	0	0	0	0
19	6	0	0	0	0	0	0	0	0	0	0
20	[illegible]	0	0	0	0	0	0	0	0	0	0
21	A	0	0	0	1	0	0	0	0	0	0
22	B	0	1	0	0	0	0	0	0	0	0
23	B	0	0	1	0	0	0	0	0	0	0
24	6	0	1	0	0	0	0	0	0	0	0
25	A	0	0	0	0	0	0	0	0	0	0
26	H	0	0	0	0	0	1	0	0	0	0
27	H	0	0	0	0	0	0	0	0	0	0
28	C	0	1	0	0	0	0	0	0	0	0
29	C	0	0	0	0	1	0	0	0	0	0
30	H	0	0	0	0	0	0	1	0	0	0
31	6	0	0	0	0	0	1	0	0	0	0
32	5	0	0	0	0	0	1	0	0	0	0
33	6	0	0	1	0	0	0	0	0	0	0
34	6	0	0	1	0	0	0	0	0	0	0
35	6	1	0	0	0	0	0	0	0	0	0
36	B	0	1	0	0	0	0	0	0	0	0
37	B	1	0	0	0	0	0	0	0	0	0
38	D	0	0	0	0	0	0	0	0	0	0
39	G	0	0	0	0	0	1	0	0	0	0
40	F	0	0	0	0	0	1	0	0	0	0
41	A	0	0	0	0	0	1	0	0	0	0
42	C	0	0	1	0	0	0	0	0	0	0
43	H	0	1	0	0	0	0	0	0	0	0
44	H	0	0	0	0	0	0	0	1	0	0
45	3	0	0	0	0	0	0	0	0	1	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

EMPLOYEES

ref	cat	¦ a	= b	= c	= d	20 e	= a	= b	= c	= d	¦ e
		-------DEC				--------INC				--------	
46	F	0	0	0	1	0	0	0	0	0	0
47	F	0	0	0	1	0	0	0	0	0	0
48	A	0	0	0	0	1	0	0	0	0	0
49	A	0	0	0	0	0	1	0	0	0	0
50	B	0	1	0	0	0	0	0	0	0	0
51	C	0	0	0	0	1	0	0	0	0	0
52	C	0	1	0	0	0	0	0	0	0	0
53	D	0	0	1	0	0	0	0	0	0	0
54	A	0	0	0	0	0	0	1	0	0	0
55	C	0	0	0	0	0	1	0	0	0	0
56	E	0	1	0	0	0	0	0	0	0	0
57	B	0	0	0	0	0	0	0	0	0	0
58	A	0	0	0	0	0	0	0	0	0	0
59	A	0	0	1	0	0	0	0	0	0	0
60	G	0	0	0	0	0	0	1	0	0	0
61	E	0	0	0	0	0	0	0	0	0	0
62	F	0	1	0	0	0	0	0	0	0	0
63	F	0	0	0	0	0	0	0	0	0	0
64	F	0	0	0	0	0	0	0	1	0	0
65	F	0	0	0	0	0	0	0	0	0	0
66	H	0	0	0	0	0	0	0	0	1	0
67	1	0	0	0	0	0	0	0	0	0	0
68	A	0	0	0	0	0	0	0	0	0	0
69	A	0	0	0	1	0	0	0	0	0	0
70	A	0	0	0	0	0	0	0	0	0	0
71	B	0	1	0	0	0	0	0	0	0	0
72	B	0	0	0	1	0	0	0	0	0	0
73	A	0	0	0	0	0	0	0	0	1	0
74	E	0	0	0	0	1	0	0	0	0	0
75	H	0	0	0	0	0	0	0	0	0	1
76	H	0	0	0	0	0	0	0	0	0	1
77	A	0	1	0	0	0	0	0	0	0	0
78	A	0	0	0	0	0	1	0	0	0	0
79	C	1	0	0	0	0	0	0	0	0	0
80	D	0	0	0	0	1	0	0	0	0	0
81	A	1	0	0	0	0	0	0	0	0	0
82	E	1	0	0	0	0	0	0	0	0	0
83	C	0	0	0	0	0	0	0	0	1	0
84	B	0	0	0	0	0	1	0	0	0	0
85	A	0	0	0	0	0	1	0	0	0	0
86	A	1	0	0	0	0	0	0	0	0	0
87	A	0	0	1	0	0	0	0	0	0	0
88	A	0	0	0	0	0	1	0	0	0	0
89	A	0	0	0	0	0	0	0	0	1	0
90	C	0	0	0	0	1	0	0	0	0	0

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref	cat	ENERGY 21 a elec	b gas	c coal	d oil	e wat	% ENERGY 22 a ele	b gas	c coal	d oil	e wat	PEOPLE 19	SITE AREA ha
1	A	1	1	0	1	1	60	31	0	5	4	40	1.58
2	A	1	1	1	1	1	33	38	14	0	15	1500	2.010
3	A	1	1	0	1	1	70	15	0	7	8	220	3.380
4	A	1	1	0	0	1	70	25	0	0	5	320	6.500
5	B	1	1	1	0	1	60	30	7	0	3	42	
6	B	1	1	0	1	1	50	27	0	20	3	1200	7.470
7	B	1	1	0	0	1	50	20	0	0	30	500	0.420
8	B	1	1	0	0	1	78	18	0	0	4	700	8.410
9	C	1	1	0	0	1	45	45	0	0	10	320	3.800
10	C	1	1	0	0	1	70	25	0	0	5	130	2.770
11	C	1	1	0	1	1	75	20	0	2	3	650	4.300
12	D	1	1	0	1	1	40	40	0	12	8	33	
13	E	1	1	0	1	1	75	15	0	5	5	400	2.200
14	E	1	1	1	1	1	50	7	40	3	2	1000	9.000
15	G	1	1	0	1	1	30	1	0	65	4	100	2.690
16	G	1	0	0	0	1	80	0	0	0	20	110	
17	B	1	1	0	0	1	22	58	0	0	20	46	
18	C	1	1	0	0	1	60	35	0	0	5	230	3.200
19	6	1	1	0	1	1	50	8	0	24	18	1300	10.500
20	C	1	1	0	0	1	75	20	0	0	5	101	1.900
21	A	1	1	0	0	1	35	54	0	0	11	350	
22	B	1	1	0	0	1	66	32	0	0	2	350	
23	B	1	1	1	0	1	45	8	40	0	7	650	8.400
24	6	1	1	1	0	1	72	3	7	0	18	1200	13.000
25	A	1	1	1	1	1	55	7	31	3	4	320	
26	H	1	1	0	1	1	40	0	0	40	20	182	
27	H	1	1	0	1	1	30	9	0	35	25	140	
28	C	1	1	0	0	1	41	2	0	0	57	240	4.660
29	C	1	1	1	1	1	51	9	37	1	2	330	5.000
30	H	1	0	0	1	1	30	0	0	60	10	107	2.500
31	6	1	1	0	1	1	48	42	0	3	7	1700	8.500
32	6	1	1	0	1	1	50	20	0	20	10	2000	15.000
33	6	1	1	0	1	1	50	20	0	20	10	1400	12.000
34	6	1	1	0	1	1	50	20	0	20	10	1000	7.000
35	6	1	1	1	1	1	50	15	10	15	10	400	2.688
36	B	1	1	0	1	1	50	20	0	20	10	300	
37	B	1	1	0	0	1	70	20	0	0	10	200	3.500
38	D	1	1	1	0	1	30	5	50	0	15	408	12.000
39	G	1	1	0	0	1	90	4	0	0	6	48	
40	F	1	1	0	0	1	70	15	0	0	15	124	1.440
41	A	1	1	0	1	1	60	12	0	20	8	450	
42	C	1	1	0	0	1	60	20	0	0	20	230	6.440
43	H	1	1	0	0	1	70	20	0	0	10	40	2.380
44	H	1	1	0	1	1	60	5	0	20	15	318	50.000
45	3	1	1	0	0	1	66	27	0	0	7	1050	0.900

MAJOR CONSUMERS QUESTIONNAIRE RESULTS

ref		ENERGY					% ENERGY					PEOPLE	SITE
		|	=	21	=	|	|	=	22	=	|	19	AREA
	cat	a	b	c	d	e	a	b	c	d	e		ha
		elec	gas	coal	oil	wat	ele	gas	coal	oil	wat		
46	F	1	1	1	0	1	40	10	40	0	10	500	9.500
47	F	1	1	0	0	1	80	15	0	0	5	45	3.250
48	A	1	1	1	1	1	70	15	5	5	5	204	
49	A	1	1	0	1	1	60	30	0	7	3	55	0.340
50	B	1	1	1	1	1	70	10	10	7	3	300	8.000
51	C	1	1	0	1	1	70	20	0	5	5	230	2.000
52	C	1	1	0	0	1	70	20	0	0	10	110	
53	D	1	1	0	1	1	50	15	0	30	5	1200	
54	A	1	1	0	0	1	50	40	0	0	10	402	4.000
55	C	1	1	0	0	1	75	20	0	0	5	548	8.000
56	E	1	1	0	1	1	50	20	0	20	10	600	105.000
57	B	1	1	1	1	1	60	20	5	10	5	1000	25.000
58	A	1	1	0	0	1	60	30	0	0	10	120	
59	A	1	1	0	0	1	60	30	0	0	10	160	5.520
60	G	1	1	0	1	1	60	20	0	10	10	135	15.000
61	E	1	1	0	0	1	50	30	0	0	20	320	
62	F	1	1	0	1	1	60	20	0	30	5	250	
63	F	1	1	0	0	1	55	20	0	0	25	250	1.460
64	F	1	1	0	0	1	50	25	0	0	25	70	1.200
65	F	1	0	0	0	1	80	0	0	0	20	220	0.450
66	H	1	1	1	1	1	50	20	10	15	5	85	
67	I	1	1	1	0	1	25	5	50	0	20	120	177.560
68	A	1	1	0	0	1	60	25	0	0	15	350	0.900
69	A	1	1	0	0	1	60	10	0	0	30	20	0.500
70	A	1	1	0	1	1	80	10	0	5	5	520	5.800
71	B	1	0	0	1	1	80	0	0	15	5	1000	2.900
72	B	1	1	0	1	1	50	20	0	10	10	965	2.760
73	A	1	1	0	0	1	70	20	0	0	10	80	1.360
74	E	1	1	0	1	1	65	20	0	10	5	109	
75	H	1	1	0	1	1	54	30	0	5	11	150	0.350
76	H	1	1	0	0	1	60	30	0	0	10	230	0.300
77	A	1	1	0	0	1	62	28	0	0	10	300	
78	A	1	1	0	0	1	30	60	0	0	10	23	0.360
79	C	1	1	0	0	1	74	24	0	0	2	310	
80	D	1	0	0	1	1	35	0	0	61	4	11	0.750
81	A	1	1	1	1	1	50	30	5	5	10	200	1.040
82	E	1	1	1	1	1	60	20	7	6	6	560	7.460
83	C	1	1	0	0	1	71	25	0	0	4	140	
84	B	1	1	0	0	1	45	45	0	0	10	45	
85	A	1	1	0	0	1	45	35	0	0	20	44	0.130
86	A	1	1	0	1	1	90	2	0	5	3	200	0.510
87	A	1	1	0	1	1	62	31	0	3	4	500	
88	A	1	1	0	0	1	55	40	0	0	5	35	0.400
89	A	1	1	0	1	1	60	20	0	10	10	45	
90	C	1	1	0	1	1	50	20	0	15	5	350	

SAMPLE OF "ALL METERED CUSTOMERS"

SUMMARY DATA FROM QUESTIONNAIRE

MINOR CONSUMERS QUESTIONNAIRE SUMMARY VERSION

REF	DOM Q4	USAGE 5	5	5	5	5	£ACTUAL	£ASSUM Q6	REGARD 7	7	7	REDUCE 8	8	8	8
1	0	0	0	0	1	0	63	66	0	1	0	0	0	0	0
2	0	0	0	1	1	0	3700	3000	1	0	0	0	1	1	0
3	0	1	0	0	1	0	1500	544	0	1	0	0	0	1	0
4	0	0	0	0	1	1	500	240	0	1	0	0	0	1	0
5	0	0	0	0	1	1	900	700	1	0	0	0	0	1	0
6	0	1	0	0	1	1	100	-1	0	1	0	0	0	1	0
7	1	0	0	0	1	0	240	240	1	0	0	1	0	0	0
8	0	0	0	0	1	0	3700	3412	1	0	0	1	1	1	0
9	0	0	0	1	1	0	6500	-1	0	1	0	0	0	1	0
10	0	0	1	0	1	0	7000	-1	1	0	0	0	1	1	0
11	0	1	0	1	1	0	6000	6170	1	0	0	0	0	1	0
12	0	0	0	1	1	0	2200	6000	0	1	0	0	1	1	0
13	0	1	1	1	1	0	1900	6350	1	0	0	0	1	1	0
14	0	0	0	0	1	0	230	-1	0	1	0	0	1	0	0
15	0	0	0	0	1	0	700	-1	0	1	0	0	1	0	0
16	0	1	0	0	1	0	700	-1	0	1	0	0	0	1	0
17	0	0	0	0	1	1	1300	1080	0	1	0	0	1	0	0
18	0	0	1	1	1	0	600	560	0	1	0	0	0	1	0
19	0	0	0	0	1	0	1900	2140	0	1	0	0	1	0	0
20	0	1	0	0	1	0	320	336	0	1	0	0	1	0	0
21	0	0	0	0	1	0	170	442	1	0	0	0	1	0	0
22	0	0	0	0	1	0	200	97	0	1	0	0	1	1	0
23	1	0	0	0	1	0	190	200	0	1	0	0	0	1	0
24	1	0	0	0	1	0	600	-1	0	1	0	0	1	0	0
25	0	1	0	0	1	0	140	120	0	1	0	0	1	0	0
26	1	0	0	0	1	0	300	-1	0	1	0	0	1	1	0
27	0	0	0	0	1	1	770	700	0	1	0	0	1	1	0
28	0	0	0	0	1	0	1100	465	0	1	0	0	1	1	0
29	0	0	0	0	1	0	1400	-1	0	1	0	0	1	1	0
30	0	0	0	0	1	1	300	-1	1	0	0	0	0	0	1
31	0	0	0	0	1	0	90	403	1	0	0	0	0	1	1
32	0	0	0	0	1	0	230	248	1	0	0	1	0	0	0
33	0	0	0	0	1	0	150	140	0	1	0	0	0	1	0
34	0	0	0	0	1	0	103	-1	0	1	0	0	1	1	0
35	0	0	0	0	1	0	250	290	0	1	0	0	1	1	0
36	1	0	0	0	1	0	90	-1	0	1	0	1	1	0	0
37	0	0	1	0	1	0	5000	4997	1	0	0	0	0	1	0
38	1	0	0	0	1	0	240	170	0	1	0	0	0	0	0
39	0	0	0	1	1	0	750	874	0	1	0	0	1	1	0
40	0	0	0	0	1	0	64	-1	0	1	0	0	1	0	0
41	1	0	0	0	1	0	65	-1	0	1	0	1	0	0	0
42	0	0	0	0	1	0	85	760	1	0	0	0	1	0	0
43	0	0	0	0	1	0	64	60	0	1	0	0	1	0	0
44	0	0	0	0	1	0	67	68	1	0	0	0	0	1	0
45	1	0	0	0	1	0	90	220	0	1	0	0	0	1	0
46	0	0	0	0	1	0	62	68	0	1	0	0	1	1	0
47	0	0	0	0	1	0	51	220	0	1	0	0	0	0	0
48	1	0	0	0	1	1	230	224	1	0	0	0	0	1	0
49	0	0	0	0	1	1	130	200	0	1	0	0	0	1	0
50	0	0	0	0	1	0	70	-1	1	0	0	0	0	0	0

MINOR CONSUMERS QUESTIONNAIRE SUMMARY VERSION

REF	DOM Q4	USAGE 5	5	5	5	5	ACTUAL	ASSUM Q6	REGARD 7	7	7	REDUCE 8	8	8	8
51	1	0	0	0	1	0	94	-1	0	1	0	0	1	0	0
52	0	0	0	0	1	1	90	-1	1	0	0	1	0	0	0
53	1	0	0	0	1	0	82	108	0	1	0	1	0	1	0
54	1	0	0	0	1	0	80	160	0	1	0	0	1	0	0
55	0	0	0	0	1	1	220	-1	0	1	0	0	0	1	0
56	0	0	0	0	1	1	250	150	0	1	0	0	1	0	0
57	1	0	0	0	1	0	104	164	0	1	0	0	1	0	0
58	1	0	0	0	1	0	90	140	0	1	0	1	1	0	0
59	0	0	0	0	1	1	140	-1	1	0	0	0	0	1	0
60	0	0	0	0	1	0	83	175	0	1	0	0	1	0	0
61	0	0	0	0	1	0	190	600	1	0	0	0	0	1	0
62	0	0	0	0	1	1	45	-1	0	1	0	0	0	1	0
63	0	0	0	0	1	0	230	234	1	0	0	0	0	1	1
64	0	0	0	0	1	1	900	-1	1	0	0	0	0	1	0
65	0	0	0	0	1	0	90	72	0	1	0	0	1	1	0
66	0	0	0	0	1	0	113	-1	0	1	0	1	1	0	0
67	0	1	0	0	1	0	120	-1	0	1	0	0	0	1	0
68	0	0	0	0	1	1	196	196	0	1	0	0	1	1	0
69	0	0	0	0	1	1	120	175	0	1	0	0	0	1	0
70	0	0	0	0	1	1	1000	1000	1	0	0	0	0	1	0
71	0	0	0	0	1	0	84	-1	0	1	0	0	0	1	0
72	1	0	0	0	1	0	92	96	0	1	0	0	0	1	0
73	0	0	0	0	1	0	650	792	1	0	0	0	0	1	0
74	1	0	0	0	1	0	75	-1	0	1	0	0	0	1	0
75	0	0	0	0	1	1	90	96	0	1	0	0	1	0	0
76	0	0	0	0	1	1	110	114	0	1	0	0	0	1	0
77	1	0	0	0	1	0	90	56	0	1	0	0	0	1	0
78	0	0	0	0	1	1	500	600	1	0	0	0	0	1	0
79	0	0	0	0	1	0	78	80	0	1	0	0	1	0	0
80	0	0	0	0	1	0	90	100	0	1	0	0	0	1	0
81	1	0	0	0	1	0	250	352	1	0	0	0	0	1	0
82	0	0	0	0	1	0	84	-1	0	1	0	0	0	1	0
83	0	0	0	0	1	0	68	94	0	1	0	0	0	1	0
84	0	0	0	0	1	0	66	-1	0	1	0	0	0	0	0
85	0	0	0	0	1	0	100	100	0	1	0	0	0	0	0
86	1	0	0	0	1	0	140	-1	0	1	0	0	0	1	0
87	0	0	0	0	1	1	65	150	0	1	0	0	0	0	0
88	1	0	0	0	1	0	87	-1	0	1	0	0	1	0	0
89	0	0	0	0	1	1	215	200	1	0	0	0	0	0	0
90	0	0	0	0	1	0	63	60	0	1	0	0	0	0	0
91	0	0	0	0	1	0	330	-1	0	1	0	0	1	0	0
92	0	0	0	0	1	0	108	99	0	1	0	0	0	0	0
93	1	0	0	0	1	0	134	-1	0	0	1	0	0	1	0
94	0	0	0	0	1	0	60	-1	0	1	0	0	0	0	0
95	0	0	0	1	1	0	550	500	1	0	0	0	0	0	0
96	1	0	0	0	1	0	56	60	1	0	0	0	0	1	0
97	0	0	0	0	1	1	500	-1	0	1	0	0	0	0	0
98	1	0	0	0	1	0	140	140	0	1	0	0	0	1	0
99	0	0	0	0	1	0	500	-1	1	0	0	0	0	1	0
100	0	1	0	0	1	0	200	200	1	0	0	0	0	1	0

AT 14/6/92

MINOR CONSUMERS QUESTIONNAIRE SUMMARY VERSION AT 14/6/92

REF	DOMV			APPEAL			P		PRESSUR				No	CONSUMPTION	AREA
	Q4	Q9		10	10	10	10	10	11	12	12	12	Q13		ha
1	0	0	1	0	0	0	0	0	1	0	0	0	0	10	25	0.03
2	0	0	1	0	0	0	0	0	1	0	0	0	0	70	6000	4.21
3	0	0	1	0	0	0	0	0	0	0	1	0	0	6	2700	0.01
4	0	0	1	0	0	0	0	0	1	0	0	0	0	73	1000	0.6
5	0	0	1	0	0	0	0	1	1	0	0	0	0	6	3000	
6	0	0	0	1	0	0	0	0	0	1	0	0	0	10	100	
7	1	1	0	1	0	0	0	0	0	1	0	0	0	5	400	0.06
8	0	0	0	0	1	0	0	0	0	1	0	0	0	50	6000	0.94
9	0	0	0	1	0	0	0	1	1	0	0	0	0	100	10000	1.5
10	0	0	0	0	0	1	0	0	0	0	0	1	0	10	11000	0.49
11	0	1	1	0	0	0	0	1	0	0	1	0	0	550	9000	
12	0	0	0	1	0	0	0	1	1	0	0	0	0	100	10000	0.63
13	0	0	0	1	0	0	0	1	0	1	0	0	0	180	3900	
14	0	0	0	1	0	0	0	0	1	0	0	0	0	50	330	0.18
15	0	0	0	0	1	0	0	0	0	0	1	0	0	300	1000	0.55
16	0	0	0	1	0	0	0	0	0	1	0	0	0	33	1100	
17	0	1	0	0	0	1	0	0	1	0	0	0	0	150	2100	
18	0	0	1	0	0	0	0	0	0	1	0	0	0	30	800	
19	0	0	0	1	0	0	0	0	0	1	0	0	0	650	3000	3.02
20	0	0	0	1	0	0	0	0	0	0	1	0	0	40	684	
21	0	0	0	1	0	0	0	0	0	1	0	0	0	20	200	0.05
22	0	0	1	0	0	0	0	0	1	0	0	0	0	25	250	0.03
23	1	1	0	1	0	0	0	0	0	1	0	0	0	4	256	0.09
24	1	0	0	1	0	0	0	0	0	1	0	0	0	17	800	1.3
25	0	0	1	0	0	0	0	0	0	0	0	1	0	28	170	0.08
26	1	0	0	1	0	0	0	1	0	1	0	0	0	4	550	3.7
27	0	0	0	1	0	0	0	1	1	0	0	0	0	238	900	1.2
28	0	0	0	0	1	0	0	0	1	0	0	0	0	262	2000	1.7
29	0	0	0	1	0	0	0	0	0	1	0	0	0	750	2500	3.2
30	0	0	0	1	0	0	0	1	1	0	0	0	0	117	700	2
31	0	0	1	0	0	0	0	0	0	1	0	0	0	15	100	0.01
32	0	0	0	0	1	0	0	0	1	0	0	0	0	5	330	0.01
33	0	0	0	1	0	0	0	0	0	1	0	0	0	12	64	0.04
34	0	0	1	0	0	0	0	0	1	0	0	0	0	17	105	0.01
35	0	0	1	0	0	0	0	1	0	0	1	0	0	4	600	
36	1	1	1	0	0	0	0	0	0	1	0	0	0	2	100	0.11
37	0	0	0	1	0	0	0	0	0	1	0	0	0	740	9000	3.4
38	1	0	0	0	0	1	0	0	0	0	1	0	0	1	75	0.04
39	0	0	1	0	0	0	0	1	1	0	0	0	0	150	1000	
40	0	0	0	0	1	0	0	1	0	0	1	0	0	5	34	0.04
41	1	0	0	0	1	0	0	0	0	0	1	0	0	1	25	0.04
42	0	0	1	0	0	0	0	0	0	1	0	0	0	20	115	
43	0	0	0	0	0	1	0	0	0	0	1	0	0	5	30	0.03
44	0	0	1	0	0	0	0	0	0	1	0	0	0	3	34	0.03
45	1	0	0	1	0	0	0	1	1	0	0	0	0	2	100	0.03
46	0	0	1	0	0	0	0	0	0	0	1	0	0	3	25	0.01
47	0	0	0	0	1	0	0	0	0	0	0	0	1	4	40	0.03
48	1	0	1	0	0	0	0	0	1	0	0	0	0	3	600	
49	0	1	0	1	0	0	0	1	1	0	0	0	0	10	350	
50	0	0	1	0	0	0	0	1	1	0	0	0	0	2	35	

AT 14/6/92

MINOR CONSUMERS QUESTIONNAIRE SUMMARY VERSION AT 14/6/92

REF	DOMV Q4	Q9	APPEAL Q10	Q10	Q10	Q10	Q10	P Q11	PRESSUR Q12	Q12	Q12	Q12	Q12	No Q13	CONSUMPTION	AREA ha
51	1	1	0	0	1	0	0	0	0	1	0	0	0	4	180	
52	0	0	1	0	0	0	0	0	0	1	0	0	0	10	160	7.71
53	1	0	0	1	0	0	0	0	0	1	0	0	0	1	84	0.04
54	1	0	0	0	0	0	1	0	0	0	0	1	0	1	70	0.03
55	0	0	1	0	0	0	0	0	0	1	0	0	0	50	290	
56	0	0	0	1	0	0	0	0	0	0	0	1	0	25	350	0.16
57	1	0	0	1	0	0	0	0	0	0	1	0	0	4	120	
58	1	0	0	1	0	0	0	0	0	1	0	0	0	2	60	0.03
59	0	0	0	0	1	0	0	0	0	0	1	0	0	10	106	
60	0	0	0	1	0	0	0	0	0	1	0	0	0	6	80	0.02
61	0	0	0	0	1	0	0	1	0	0	1	0	0	8	236	0.09
62	0	0	0	0	1	0	0	0	0	1	0	0	0	4	91	0.03
63	0	0	0	1	0	0	0	0	0	1	0	0	0	15	30	0.3
64	0	0	0	1	0	0	0	0	0	0	1	0	0	8	2000 .	0.06
65	0	0	0	1	0	0	0	1	0	1	0	0	0	1	160	0.02
66	0	1	0	1	0	0	0	1	0	1	0	0	0	11	90	0.05
67	0	0	0	1	0	0	0	0	1	0	0	0	0	7	135	
68	0	0	0	1	0	0	0	0	1	0	0	0	0	20	230	0.08
69	0	0	0	1	0	0	0	0	0	1	0	0	0	14	150	0.34
70	0	0	1	0	0	0	0	0	0	0	1	0	0	2	2900	0.03
71	0	0	0	1	0	0	0	0	0	1	0	0	0	25	74	0.03
72	1	0	1	0	0	0	0	0	0	0	1	0	0	2	71	0.03
73	0	0	1	0	0	0	0	0	1	0	0	0	0	30	1000	0.05
74	1	0	1	0	0	0	0	0	0	0	0	1	0	2	65	0.06
75	0	0	0	0	0	1	0	0	0	0	0	1	0	4	98	0.03
76	0	0	0	1	0	0	0	0	0	1	0	0	0	6	350	0.55
77	1	0	0	1	0	0	0	0	0	1	0	0	0	1	66	0.05
78	0	0	0	1	0	0	0	0	1	0	0	0	0	2	1400	
79	0	0	0	1	0	0	0	0	0	0	1	0	0	11	68	0.01
80	0	1	0	1	0	0	0	0	0	0	1	0	0	6	50	0.02
81	1	0	1	0	0	0	0	0	1	0	0	0	0	2	600	
82	0	0	1	0	0	0	0	0	0	1	0	0	0	2	80	
83	0	0	1	0	0	0	0	1	1	0	0	0	0	2	41	
84	0	0	1	0	0	0	0	0	1	0	0	0	0	4	44	
85	0	0	0	1	0	0	0	0	0	1	0	0	0	3	33	0.01
86	1	0	0	0	0	1	0	1	1	0	0	0	0	2	137	
87	0	0	1	0	0	0	0	0	0	0	0	1	0	5	34	0.17
88	1	0	1	0	0	0	0	1	1	0	0	0	0	2	83	0.01
89	0	0	1	0	0	0	0	0	1	0	0	0	0	4	310	
90	0	0	1	0	0	0	0	0	0	1	0	0	0	3	26	
91	0	0	1	0	0	0	0	1	0	0	1	0	0	30	900	
92	0	0	1	0	0	0	0	0	0	1	0	0	0	13	70	0.08
93	1	1	0	1	0	0	0	1	1	0	0	0	0	2	450	0.44
94	0	0	1	0	0	0	0	1	0	1	0	0	0	3	20	
95	0	0	0	1	0	0	0	1	1	0	0	0	0	17	850	
96	1	0	1	0	0	0	0	0	1	0	0	0	0	1	10	0.02
97	0	0	1	0	0	0	0	0	0	0	0	0	1	14	900	
98	1	1	0	0	1	0	0	1	0	1	0	0	0	2	170	0.03
99	0	0	0	1	0	0	0	0	0	1	0	0	0	4	800	
100	0	0	1	0	0	0	0	0	0	0	0	0	1	12	300	0.03

A.O.	REF. NR.	QUARTERLY CONSUMPTIONS 1	2	3	4	ANNUAL TOTAL	M2	PEOPLE	M. SIZE	COMMENTS
W	M1	706	910	261	349	2226	87692	11	50mm	
N	M2	524	618	0	0	1142	0	0	50mm	Shut down
T	M3	347	206	386	284	1223	4875		80mm	
T	M4	177	161	143	130	611	19614		20mm	
W	M5	2057	4146	3467	1630	11300			100mm	Premises closing
W	M6	885	885	1217	476	3463	90925	1170	50mm	
W	M7	2693	1292	1284	1284	6553	19782	58	40mm	
T	M8	1371	1735	1378	1635	6119	24200	250	40mm	
T	M9	1927	1898	1856	1581	7262	9966	250	50mm	
W	M10	1851	1840	1905	1685	7281	92	25	80mm	
N	M11	1872	3759	2915	3639	12185			40mm	
W	M12	2260	1941	2423	2171	8795	32375	141	40mm	
N	M13	3233	401	1731	1778	7143	62726	105	25mm	
T	M14	2863	1983	1780	2052	8678	2043	28	50mm	
T	M15	3783	4090	3586	3678	15137	7826		40mm	
T	M16	1735	1671	1968	1308	6682		17	50mm	
T	M17	3283	2876	2744	2379	11282	5574	45	80mm	
N	M18	11183	12032	11008	14416	48639	1618760	520	80mm	Golf course
T	M19	4151	3229	2845	8753	18978			50mm	
T	M20	530	520	839	907	2796	17976	120	40mm	
T	M21	726	903	75	1061	2765			50mm	
N	M22	10538	8600	8396	9531	37065	169970	600	80mm	
N	M23	51	42	14	14	121	566566	5	50mm	
T	M24	1821	1688	2728	1602	7839	25908		80mm	Unsure of boundary
W	M25	2846	3299	3724	5413	15282	3000	25	40mm	
T	M26	7146	4896	4874	5081	21997	37869		50mm	Neurosurgery centre
T	M27	3252	3150	3746	3047	13195	45702		80mm	
W	M28	3169	4400	4726	3807	16102	16188	59	40mm	
T	M29	4977	5607	4928	3306	18818	65694	241	100mm	
T	M30	3091	1915	1460	1379	7845				
T	M31	2247	466	429	876	4018		250	50mm	
T	M32	1707	3331	2706	2387	10131			50mm	
T	M33	7567	8368	10219	7292	33446			100mm	Closed down
N	M34	3667	4050	2497	2272	12486	8094	21	40mm	
W	M35	1602	1936	1375	1146	6059	102737	600	25mm	? Meter Size
N	M36	3048	3634	3358	6230	16270			50mm	
N	M37	2105	2067	15056	551	19779			20mm	
W	M38	4115	4160	4187	2470	14932	77319	200	100mm	Outline unclear
N	M39	2493	2397	2212	2338	9440	951021	2	15mm	
T	M40	109985	112171	137295	158586	518037			100mm	
W	M41	1031	1903	1750	1520	6204	280091	160	80mm	Outline unclear
W	M42	9554	9556	10362	8908	38380	36422	500	80mm	
W	M43	659	1195	1632	1997	5483			25mm	
T	M44	2152	1467	2462	2850	8931	92795	90	100mm	
W	M45	2649	3819	973	926	8367	236280	40	50mm	Inc' claypits but unclear
W	M46	969	1724	1204	1973	5870	6070	4	40mm	
W	M47	0	339	407	467	1213	3891	50	40mm	
W	M48	1664	1477	1630	1375	6146	33906	1288	40mm	
W	M49	1113	998	1046	754	3911	117103	20234	25mm	
T	M50	2397	2428	2437	504	7766			25mm	
N	M51	1960	1793	1707	1707	7167			40mm	
W	M52	2850	461	3199	3163	9673	150	59	50mm	Bounary not clear
W	M53	1136	1844	1530	590	5100	11377	7	40mm	
W	M54	1904	2415	2732	1450	8501	119753	98	40mm	
W	M55	3169	3108	2779	2423	11479	232	28	25mm	
N	M56	25471	25079	28707	26841	106098			80mm	
N	M57	1055	1370	1713	1966	6104	2601	100	40mm	

MONTHLY METERS

A.O.	REF. NR.	QUARTERLY CONSUMPTIONS 1	2	3	4	ANNUAL TOTAL	M2	PEOPLE	M. SIZE	COMMENTS
W	M58	334	404	356	440	**1534**	303517	2	25	94 Cattle
N	M59	4253	3528	4375	3930	**16086**	8094	150	80	
T	M60	1494	1482	1303	2341	**6620**			40mm	
W	M61	0	0	0	0	**0**	3000	18	50mm	
N	M62	1831	914	1021	689	**4455**	93079	100	25	
W	M63	3216	877	798	1239	**6130**	26252	3400	40mm	
T	M64	13715	10657	14062	12979	**51413**			80mm	
T	M65	1906	2110	1932	1784	**7732**	7200	35	80mm	
W	M66	1827	1075	1585	1591	**6078**	3600	35	40mm	
N	M67	65570	73450	101720	101110	**341850**			300mm	
W	M68	5210	5729	6173	4731	**21843**			50mm	
W	M69	4	63	57	66	**190**	10630	35	25mm	
T	M70	3437	4191	3886	13019	**24533**		150	80mm	
W	M71	1828	2083	1929	1819	**7659**			50mm	
W	M72	1210	1895	1913	2491	**7509**	800	50	40mm	
N	M73	1699	141	1342	178	**3360**			50mm	
T	M74	2823	1725	1422	1748	**7718**	7187		50mm	
T	M75	2148	2437	2363	2726	**9674**			40mm	
W	M76	13611	12771	11933	10554	**48869**	13864	265	100mm	
T	M77	1723	2451	2481	1798	**8453**	383745		25mm	
N	M78	1248	1170	1490	850	**4758**	4552	30	50mm	
T	M79	1749	1832	2223	2022	**7826**	108447		80mm	
N	M80	3359	1861	1726	2301	**9247**			40mm	
W	M81	2947	4444	2680	4244	**14315**	34399	310	80mm	
T	M82	12365	9779	15414	14323	**51881**	61442	24203	80mm	Inc' foundry & works
N	M83	1930	1645	1519	1414	**6508**	149735	2000	50mm	
N	M84	19175	17680	17969	23260	**78084**			100mm	
N	M85	553	328	1031	1139	**3051**			25mm	

MONTHLY METERS

A.O.	REF. NR.	QUARTERLY CONSUMPTIONS 1	2	3	4	ANNUAL TOTAL	M2	PEOPLE	M. SIZE	COMMENTS
W	Q1	115	197	180	152	**644**			25mm	
W	Q2	2	3	13	18	**36**	224	6	20mm	
T	Q3	343	284	293	281	**1201**	4412		40mm	
T	Q4	0	13	5	15	**33**	86		15mm	
T	Q5	32	31	65	3	**131**	689		20mm	
W	Q6	743	875	763	1235	**3616**	27482	465	40mm	
W	Q7	544	569	474	169	**1756**	6726	280	25mm	
W	Q8	14	0	11	7	**32**	98	1	15mm	
W	Q9	102	115	106	105	**428**	3319	100	15mm	
W	Q10	8	12	12	7	**39**	554	6	20mm	
W	Q11	53	85	22	23	**183**	12609	7	15mm	EXC' CLAYPITS
W	Q12	405	404	191	191	**1191**	25564	32	20mm	
W	Q13	21	18	18	33	**90**	559	4	15mm	
W	Q14	100	1538	55	62	**1755**	15905		40mm	BOUNDARY UNCLEAR
W	Q15	2	7	0	15	**24**			15mm	
W	Q16	8	8	7	8	**31**	158	5	15mm	
W	Q17	0	0	0	1	**1**	146	2	15mm	
W	Q18	97	115	97	66	**375**	3000	6	20mm	
T	Q19	8	46	25	21	**100**			20mm	
T	Q20	104	183	139	104	**530**	3252	200	15mm	
T	Q21	185	17	157	264	**623**	2229	42	20mm	
T	Q22	16	16	18	11	**61**	190	5	15mm	
N	Q23	6	549	271	208	**1034**	40469	206	40mm	
T	Q24	5	8	6	2	**21**		3	15mm	
T	Q25	911	1282	229	230	**2652**	30000	31	25mm	
N	Q26	103	118	110	100	**431**	4047	12	15mm	
N	Q27	65	66	54	63	**248**	2023	6	15mm	
N	Q28	65	236	117	121	**539**	117360	2	15mm	
N	Q29	2	1	15	9	**27**	4047	1	20mm	
N	Q30	150	346	125	193	**814**	404690	3	15mm	
N	Q31	112	42	127	98	**379**	768911	2	15mm	
T	Q32	53	83	113	83	**332**			15mm	
T	Q33	109	75	99	134	**417**	329			
T	Q34	38	28	36	39	**141**			20mm	
T	Q35	0	0	256	256	**512**	539		20mm	
T	Q36	19	19	4	13	**55**	98		20mm	
T	Q37	0	0	120	164	**284**	202345	2	25mm	
T	Q38	2	3	3	1	**9**	4685		15mm	
T	Q39	1	21	11	9	**42**	690		15mm	
T	Q40	2	18	10	8	**38**	250	6	15mm	
T	Q41	124	172	769	314	**1379**	4987		15mm	
T	Q42	539	539	639	756	**2473**			80mm	
T	Q43	28	21	13	13	**75**			15mm	
T	Q44	8	8	5	9	**30**			15mm	
T	Q45	3	3	36	27	**69**	418	12	15mm	
N	Q46	324	128	263	260	**975**	18211	6	25mm	
N	Q47	0	0	3	1	**4**			15mm	
N	Q49	301	343	311	314	**1269**	7797		25mm	
N	Q50	82	25	74	66	**247**			15mm	
T	Q51	1	0	2	26	**29**			15mm	
W	Q52	0	10	3	7	**20**	1618	20	20mm	
W	Q53	0	0	0	640	**640**			50mm	
N	Q54	217	0	120	139	**476**	40469	3	15mm	
N	Q55	0	155	511	312	**978**	10117	4	20mm	
N	Q56	3	21	4	8	**36**			15mm	

QUARTERLY METERS

A.O.	REF. NR.	QUARTERLY CONSUMPTIONS 1	2	3	4	ANNUAL TOTAL	M2	PEOPLE	M. SIZE	COMMENTS
N	Q57	142	788	371	434	**1735**			40mm	
N	Q58	16	6	7	11	**40**			25mm	
N	Q59	296	1116	653	590	**2655**			80mm	
N	Q60	14	45	25	25	**109**			25mm	
T	Q61	9	9	8	0	**26**	110		25mm	
N	Q62	89	107	98	96	**390**	6070	25	20mm	
N	Q63	0	6	6	3	**15**	18211	2	25mm	
N	Q64	9	6	8	8	**31**	148	7	20mm	
N	Q65	11	31	14	17	**73**			15mm	
W	Q66	73	73	53	58	**257**	100	1	15mm	
W	Q67	0	0	1	0	**1**	120	1	15mm	
W	Q68	41	44	5	51	**141**	1115	10	20mm	
W	Q69	44	70	48	81	**243**	10000	15	15mm	
W	Q70	64	31	32	48	**175**	42492	3	15mm	FIELDS UNCLEAR
W	Q71	56	79	90	77	**302**	1403	8	15mm	
T	Q72	22	35	209	292	**558**	387	30	25mm	
T	Q73	723	904	1382	994	**4003**	23024	430	50mm	
T	Q74	0	8	157	43	**208**	41		20mm	SIGNAL BOX ?
T	Q75	16	30	29	28	**103**	2016	6	15mm	
T	Q76	7	10	0	6	**23**	272	5	20mm	
T	Q77	16	36	2	17	**71**	121	1	15mm	
W	Q78	3	2	7	3	**15**	63	3	20mm	
W	Q79	2	2	95	49	**148**	378	1	20mm	
W	Q80	1616	67	67	444	**2194**	42770	8	20mm	BOUNDARY UNCLEAR
W	Q81	63	41	71	52	**227**	3270	12	15mm	
W	Q82	5	7	4	6	**22**	3000	41	20mm	
W	Q83	157	98	1394	432	**2081**	71342		25mm	BOUNDARY UNCLEAR
W	Q84	301	183	436	266	**1186**	7118		40mm	
T	Q85	875	1061	1082	1044	**4062**	10000	200	40mm	
T	Q86	1425	607	1041	791	**3864**	43000		25mm	
T	Q87	68	75	69	70	**282**		23	15mm	
T	Q88	137	267	237	234	**875**		7	40mm	
N	Q89	18	10	32	9	**69**	230	5	15mm	
N	Q90	8	6	3	4	**21**	70	2	15mm	
N	Q91	19	22	2	18	**61**			15mm	
N	Q92	87	72	98	46	**303**	80938	0	15mm	
N	Q93	252	75	67	150	**544**			15mm	
N	Q94	55	57	73	60	**245**	4047	12	15mm	
N	Q95	15	19	23	23	**80**	51	3	15mm	
N	Q96	97	126	120	120	**463**	202345	0	15mm	
N	Q97	70	81	188	103	**442**			20mm	
T	Q98	8	22	26	23	**79**	363		15mm	
T	Q99	54	150	19	111	**334**			15mm	
T	Q100	62	36	35	39	**172**			20mm	
T	Q101	133	81	48	78	**340**			20mm	
T	Q102	58	29	9	26	**122**	176	13	15mm	
T	Q103	19	4	8	20	**51**	58	4	15mm	
T	Q104	155	228	122	165	**670**	12140	1075	50mm	
T	Q105	9	4	7	6	**26**	625	2	15mm	
T	Q106	18	70	56	58	**202**		269	15mm	
T	Q107	512	518	597	533	**2160**	177	3	25mm	
T	Q108	22	25	16	22	**85**		477	25mm	
T	Q109	87	164	378	179	**808**		10	20mm	
N	Q110	24	29	30	24	**107**	40469	2	25mm	
N	Q111	7	7	10	7	**31**	1012	3	15mm	

QUARTERLY METERS

A.O.	REF. NR.	QUARTERLY CONSUMPTIONS 1	2	3	4	ANNUAL TOTAL	M2	PEOPLE	M. SIZE	COMMENTS
T	Q112	203	194	188	197	**782**			50mm	
T	Q113	42	78	82	76	**278**			20mm	
T	Q114	15	11	1	10	**37**			20mm	
T	Q115	16	25	24	25	**90**			15mm	
N	Q116	21	21	29	21	**92**			15mm	
N	Q117	3	4	42	8	**57**			15mm	
N	Q118	51	69	144	89	**353**	40469	2	20mm	
N	Q119	87	102	100	100	**389**	202345	2	15mm	
N	Q120	2	6	4	5	**17**	90	2	15mm	
N	Q121	12	17	22	21	**72**			15mm	
W	Q122	308	347	251	332	**1238**	1662	30	25mm	
W	Q123	11	17	16	16	**60**			15mm	
W	Q124	26	16	8	14	**64**			20mm	
W	Q125	22	19	0	18	**59**	203	3	15mm	
W	Q126	5	5	8	8	**26**	108	3	15mm	
W	Q127	381	140	150	67	**738**	489	9	15mm	
W	Q128	13	13	9	13	**48**	157	11	15mm	
W	Q129	73	44	87	17	**221**			15mm	
W	Q130	62	66	68	80	**276**	22012		15mm	BOUNDARY UNCLEAR
W	Q131	34	21	13	28	**96**	26376		20mm	BOUNDARY UNCLEAR
W	Q132	0	42	63	59	**164**	4070	11	20mm	
W	Q133	1	54	4	5	**64**	176	2	15mm	
W	Q134	4	4	1	3	**12**	106	2	15mm	
T	Q135	127	141	127	131	**526**	3437	14	20mm	
T	Q136	1	0	0	0	**1**	142	1	15mm	
T	Q137	160	44	254	116	**574**	6914		20mm	NOT CLEARLY DEFINE
T	Q138	1	0	1	1	**3**			15mm	
T	Q139	42	70	43	63	**218**			25mm	
W	Q140	123	78	67	81	**349**	186	19	15mm	
W	Q141	18	14	15	15	**62**	199	4	15mm	
W	Q142	15	22	28	24	**89**	338	16	15mm	
W	Q143	0	0	25	7	**32**	84	4	15mm	
W	Q144	195	98	168	122	**583**	2903	92	15mm	
W	Q145	3	2	2	2	**9**			15mm	
T	Q146	12	11	13	12	**48**	278	5	15mm	
T	Q147	62	56	55	55	**228**		2	20mm	
N	Q148	12	12	92	51	**167**			20mm	
N	Q149	60	17	38	3	**118**	8094	80	40mm	
N	Q150	0	0	4	1	**5**			20mm	
N	Q151	400	275	327	351	**1353**			25mm	
N	Q152	265	235	298	236	**1034**			20mm	
N	Q153	12	15	18	14	**59**			15mm	
T	Q154	1	3	2	3	**9**	1197	3	15mm	
T	Q155	9	13	7	11	**40**	1123		15mm	
T	Q156	507	274	286	290	**1357**	7741	39	25mm	
T	Q157	4	12	11	9	**36**			20mm	
T	Q158	23	14	11	13	**61**	464	7	20mm	
T	Q159	0	0	1	4	**5**	253	2	20mm	
T	Q160	297	315	131	269	**1012**	149	5	15mm	
T	Q161	3	2	1	2	**8**		1	15mm	
T	Q162	295	339	304	278	**1216**			25mm	
N	Q163	191	113	193	62	**559**	6070	200	20mm	
N	Q164	39	69	50	71	**229**	36	8	15mm	
N	Q165	93	71	201	200	**565**	105219	4	15mm	
N	Q166	368	396	400	356	**1520**			80mm	

QUARTERLY METERS

A.O.	REF. NR.	QUARTERLY CONSUMPTIONS 1	2	3	4	ANNUAL TOTAL	M2	PEOPLE	M. SIZE	COMMENTS
N	Q167	12	22	32	71	**137**			20mm	
N	Q168	0	0	0	54	**54**			15mm	
N	Q169	24	12	14	11	**61**			20mm	
W	Q170	22	9	14	12	**57**	142		15mm	
W	Q171	73	50	136	42	**301**	3403		15mm	
W	Q172	306	55	55	55	**471**			20mm	
N	Q173	14	5	1	3	**23**			15mm	
N	Q174	6	0	0	0	**6**			15mm	
N	Q175	9	2	9	9	**29**			15mm	
N	Q176	94	68	101	100	**363**	74	6	15mm	
N	Q177	2612	1162	1703	286	**5763**	2303	10	20mm	
N	Q178	0	11	4	11	**26**	292	5	15mm	
N	Q179	2	10	24	19	**55**			20mm	VOID
N	Q180	15	1	2	18	**36**	2023	10	15mm	
T	Q181	10	21	27	23	**81**	4091	10	25mm	NOT CLEAR

QUARTERLY METERS

GROUP J MODERATOR/HOUSEHOLD DATA TESTS 1991/1992

ACOR MODERATOR ANALYSIS BY STREET/PROPERTY AS AT 1 TOR
GROU J SEPTEMBER TO AUGUST 8 TESTS: INCLUDING LAST

ref	REST 1 NO 2YES	GROUPNO	OF PROP	MONTH OF TEST	FIRST READING	PLOT SIZE ■3	LAST READING	DURATION DAYS	CON'S ■3	DAILY CON'S l/PROP/D	METER SPEC (■3/hr)	AGE-BASE 92 PROP YRS	MAIN YRS	0 ADUL
1	2	6	1	1	0	1200	5	43	5	110	1.00	40	2	1
2	2	6	1	2	5	1200	6	14	2	109	1.00	40	2	1
3	2	6	1	3	6	1200	10	28	3	116	1.00	40	2	1
4	2	6	1	4	10	1200	19	94	10	103	1.00	40	2	1
5	2	6	1	5	19	1200	24	47	5	104	1.00	40	2	1
6	2	6	1	6	24	1200	25	12	1	99	1.00	40	2	1
7	1	6	1	7	25	1200	29	32	3	103	1.00	40	2	1
8	1	6	1	8	29	1200	34	32	5	168	1.00	40	2	1
9	1	6	1	1	0	1200	39	43	39	910	1.00	40	2	4
10	1	6	1	2	39	1200	50	14	11	777	1.00	40	2	4
11	1	6	1	3	50	1200	79	28	29	1034	1.00	40	2	4
12	1	6	1	4	79	1200	168	94	88	940	1.00	40	2	4
13	1	6	1	5	168	1200	214	47	46	979	1.00	40	2	4
14	1	6	1	6	214	1200	224	12	10	867	1.00	40	2	4
15	2	6	1	7	224	1200	253	32	29	902	1.00	40	2	4
16	2	6	1	8	253	1200	273	32	20	636	1.00	40	2	4
17	2	6	1	1	0	1200	15	43	15	349	1.00	40	2	2
18	2	6	1	2	15	1200	20	14	5	321	1.00	40	2	2
19	2	6	1	3	20	1200	28	28	8	302	1.00	40	2	2
20	2	6	1	4	28	1200	57	94	29	312	1.00	40	2	2
21	2	6	1	5	57	1200	73	47	15	321	1.00	40	2	2
22	2	6	1	6	73	1200	76	12	4	325	1.00	40	2	2
23	1	6	1	7	76	1200	86	32	9	284	1.00	40	2	2
24	1	6	1	8	86	1200	94	32	9	275	1.00	40	2	2
25	1	6	1	1	0	1200	11	43	11	255	1.00	40	2	2
26	1	6	1	2	11	1200	14	14	3	203	1.00	40	2	2
27	1	6	1	3	14	1200	27	28	13	456	1.00	40	2	2
28	1	6	1	4	27	1200	52	94	25	265	1.00	40	2	2
29	1	6	1	5	52	1200	63	47	11	233	1.00	40	2	2
30	1	6	1	6	63	1200	66	12	3	240	1.00	40	2	2
31	2	6	1	7	66	1200	72	32	6	191	1.00	40	2	2
32	2	6	1	8	72	1200	77	32	5	171	1.00	40	2	2
33	2	6	1	1	0	1200	54	43	53	1244	1.00	40	2	3
34	2	6	1	2	54	1200	70	14	16	1164	1.00	40	2	3
35	2	6	1	3	70	1200	97	28	27	972	1.00	40	2	3
36	2	6	1	4	97	1200	330	94	233	2475	1.00	40	2	3
37	2	6	1	5	330	1200	379	47	50	1055	1.00	40	2	3
38	2	6	1	6	379	1200	393	12	13	1103	1.00	40	2	3
39	1	6	1	7	393	1200	427	32	35	1079	1.00	40	2	3
40	1	6	1	8	427	1200	457	32	30	943	1.00	40	2	3
41	1	6	1	1	0	1200	21	43	21	489	1.00	40	2	3
42	1	6	1	2	21	1200	29	14	8	545	1.00	40	2	3
43	1	6	1	3	29	1200	41	28	13	448	1.00	40	2	3
44	1	6	1	4	41	1200	80	94	38	408	1.00	40	2	3
45	1	6	1	5	80	1200	112	47	32	687	1.00	40	2	3
46	1	6	1	6	112	1200	121	12	9	712	1.00	40	2	3
47	2	6	1	7	121	1200	140	32	19	604	1.00	40	2	3
48	2	6	1	8	140	1200	153	32	13	410	1.00	40	2	3
49	2	6	1	1	0	1200	39	43	39	900	1.00	40	2	2
50	2	6	1	2	39	1200	53	14	14	997	1.00	40	2	2
51	2	6	1	3	53	1200	73	28	21	736	1.00	40	2	2
52	2	6	1	4	73	1200	142	94	68	728	1.00	40	2	2
53	2	6	1	5	142	1200	175	47	33	704	1.00	40	2	2
54	2	6	1	6	175	1200	187	12	12	975	1.00	40	2	2

ACOR MODERATOR ANALYSIS BY STREET/PROPERTY AS AT 1 TOR
GROU J SEPTEMBER TO AUGUST 8 TESTS: INCLUDING LAST

ref	REST 1 NO 2YRS	GROUP	NO OF PROP	MONTH OF TEST	FIRST READING	PLOT SIZE m3	LAST READING	DURATION DAYS	CON'S m3	DAILY CON'S l/PROP/D	METER SPEC (m3/hr)	AGE-BASE 92 PROP YRS	MAIN YRS	0 ADUL
55	1	6	1	7	187	1200	218	32	31	977	1.00	40	2	2
56	1	6	1	8	218	1200	243	32	25	774	1.00	40	2	2
57	1	6	1	1	0	1200	13	43	12	289	1.00	40	2	2
58	1	6	1	2	13	1200	17	14	4	299	1.00	40	2	2
59	1	6	1	3	17	1200	25	28	9	306	1.00	40	2	2
60	1	6	1	4	25	1200	55	94	29	311	1.00	40	2	2
61	1	6	1	5	55	1200	70	47	15	328	1.00	40	2	2
62	1	6	1	6	70	1200	75	12	5	378	1.00	40	2	2
63	2	6	1	7	75	1200	89	32	14	437	1.00	40	2	2
64	2	6	1	8	89	1200	95	32	7	216	1.00	40	2	2
65	2	6	1	1	0	1200	15	43	15	353	1.00	40	2	2
66	2	6	1	2	15	1200	20	14	5	364	1.00	40	2	2
67	2	6	1	3	20	1200	31	28	10	362	1.00	40	2	2
68	2	6	1	4	31	1200	65	94	34	364	1.00	40	2	2
69	2	6	1	5	65	1200	83	47	18	384	1.00	40	2	2
70	2	6	1	6	83	1200	85	13	2	154	1.00	40	2	2
71	2	6	1	7	85	1200	96	31	11	366	1.00	40	2	2
72	2	6	1	8	96	1200	107	32	10	323	1.00	40	2	2
73	1	6	1	1	0	1200	31	43	31	724	1.00	40	2	4
74	1	6	1	2	31	1200	40	14	8	599	1.00	40	2	4
75	1	6	1	3	40	1200	59	28	20	699	1.00	40	2	4
76	1	6	1	4	59	1200	160	94	101	1072	1.00	40	2	4
77	1	6	1	5	160	1200	216	47	56	1194	1.00	40	2	4
78	1	6	1	6	216	1200	227	13	11	841	1.00	40	2	4
79	2	6	1	7	227	1200	258	31	31	1004	1.00	40	2	4
80	2	6	1	8	258	1200	279	32	21	644	1.00	40	2	4
81	2	6	1	1	0	1200	29	43	29	667	1.00	40	2	3
82	2	6	1	2	29	1200	37	14	9	614	1.00	40	2	3
83	2	6	1	3	37	1200	52	28	15	533	1.00	40	2	3
84	2	6	1	4	52	1200	105	94	53	561	1.00	40	2	3
85	2	6	1	5	105	1200	140	47	35	745	1.00	40	2	3
86	2	6	1	6	140	1200	148	13	8	603	1.00	40	2	3
87	1	6	1	7	148	1200	181	31	33	1063	1.00	40	2	3
88	1	6	1	8	181	1200	202	32	21	645	1.00	40	2	3
89	1	6	1	1	64	1200	66	43	3	59	1.00	40	2	1
90	1	6	1	2	66	1200	67	14	1	64	1.00	40	2	1
91	1	6	1	3	67	1200	69	28	1	49	1.00	40	2	1
92	1	6	1	4	69	1200	74	94	5	58	1.00	40	2	1
93	1	6	1	5	74	1200	79	47	5	105	1.00	40	2	1
94	1	6	1	6	79	1200	80	13	1	52	1.00	40	2	1
95	2	6	1	7	80	1200	83	31	4	116	1.00	40	2	1
96	2	6	1	8	83	1200	84	32	1	41	1.00	40	2	1
97	2	6	1	1	0	1200	26	43	26	598	1.00	40	2	2
98	2	6	1	2	26	1200	33	14	7	527	1.00	40	2	2
99	2	6	1	3	33	1200	44	28	11	385	1.00	40	2	2
100	2	6	1	4	44	1200	92	94	48	508	1.00	40	2	2
101	2	6	1	5	92	1200	121	47	29	627	1.00	40	2	2
102	2	6	1	6	121	1200	130	13	8	641	1.00	40	2	2
103	1	6	1	7	130	1200	150	31	21	673	1.00	40	2	2
104	1	6	1	8	150	1200	169	32	19	595	1.00	40	2	2
105	1	6	1	1	0	1500	16	44	16	358	1.00	15	2	2
106	1	6	1	2	16	1500	21	14	5	343	1.00	15	2	2
107	1	6	1	3	21	1500	30	28	10	340	1.00	15	2	2
108	1	6	1	4	30	1500	61	96	31	320	1.00	15	2	2

ACOR MODERATOR ANALYSIS BY STREET/PROPERTY AS AT 1 TOR
GROU J SEPTEMBER TO AUGUST 8 TESTS: INCLUDING LAST

ref	REST 1 NO 2YES	GROUP	NO OF PROP	MONTH OF TEST	FIRST READING	PLOT SIZE m3	LAST READING	DURATION DAYS	CON'S m3	DAILY CON'S l/PROP/D	METER SPEC (m3/hr)	AGE-BASE 92 PROP YRS	MAIN YRS	0 ADUL
109	1	6	1	5	61	1500	85	46	25	536	1.00	15	2	2
110	1	6	1	6	85	1500	89	14	4	264	1.00	15	2	2
111	1	6	1	7	89	1500	108	26	19	739	1.00	15	2	2
112	1	6	1	8	108	1500	120	35	12	339	1.00	15	2	2
113	1	6	1	1	0	1500	13	44	13	285	1.00	15	2	2
114	1	6	1	2	13	1500	17	14	4	306	1.00	15	2	2
115	1	6	1	3	17	1500	24	28	8	273	1.00	15	2	2
116	1	6	1	4	24	1500	58	96	33	346	1.00	15	2	2
117	1	6	1	5	58	1500	70	46	12	265	1.00	15	2	2
118	1	6	1	6	70	1500	76	14	6	438	1.00	15	2	2
119	2	6	1	7	76	1500	87	26	11	413	1.00	15	2	2
120	2	6	1	8	87	1500	96	35	9	263	1.00	15	2	2
121	2	6	1	1	0	1500	16	44	16	370	1.00	15	2	2
122	2	6	1	2	16	1500	21	14	4	317	1.00	15	2	2
123	2	6	1	3	21	1500	32	28	11	409	1.00	15	2	2
124	2	6	1	4	32	1500	66	96	33	348	1.00	15	2	2
125	2	6	1	5	66	1500	71	46	6	121	1.00	15	2	2
126	2	6	1	6	71	1500	76	14	5	375	1.00	15	2	2
127	1	6	1	7	77	1500	90	26	13	490	1.00	15	2	2
128	1	6	1	8	90	1500	105	35	15	423	1.00	15	2	2
129	1	6	1	1	0	1500	99	44	99	2246	1.00	15	2	2
130	1	6	1	2	99	1500	149	14	50	3598	1.00	15	2	2
131	1	6	1	3	149	1500	273	28	124	4414	1.00	15	2	2
132	1	6	1	4	273	1500	333	96	60	624	1.00	15	2	2
133	1	6	1	5	333	1500	412	46	80	1729	1.00	15	2	2
134	1	6	1	6	412	1500	424	14	12	853	1.00	15	2	2
135	2	6	1	7	424	1500	492	26	68	2623	1.00	15	2	2
136	2	6	1	8	492	1500	536	35	43	1237	1.00	15	2	2
137	2	6	1	1	0	1500	24	44	24	540	1.00	15	2	2
138	2	6	1	2	24	1500	30	14	6	454	1.00	15	2	2
139	2	6	1	3	30	1500	44	28	14	489	1.00	15	2	2
140	2	6	1	4	44	1500	93	96	49	512	1.00	15	2	2
141	2	6	1	5	93	1500	163	46	70	1515	1.00	15	2	2
142	2	6	1	6	163	1500	173	14	11	773	1.00	15	2	2
143	1	6	1	7	173	1500	233	26	60	2302	1.00	15	2	2
144	1	6	1	8	233	1500	265	35	32	903	1.00	15	2	2
145	2	6	1	1	0	1500	10	44	10	226	1.00	15	2	2
146	2	6	1	2	10	1500	13	14	3	183	1.00	15	2	2
147	2	6	1	3	13	1500	19	28	7	233	1.00	15	2	2
148	2	6	1	4	19	1500	37	96	18	191	1.00	15	2	2
149	2	6	1	5	37	1500	46	46	9	195	1.00	15	2	2
150	2	6	1	6	46	1500	49	14	3	183	1.00	15	2	2
151	1	6	1	7	49	1500	56	26	7	267	1.00	15	2	2
152	1	6	1	8	56	1500	61	35	5	151	1.00	15	2	2
153	1	6	1	1	0	1500	62	44	62	1416	1.00	15	2	4
154	1	6	1	2	62	1500	82	14	19	1374	1.00	15	2	4
155	1	6	1	3	82	1500	121	28	40	1422	1.00	15	2	4
156	1	6	1	4	121	1500	259	96	137	1432	1.00	15	2	4
157	1	6	1	5	259	1500	320	46	61	1327	1.00	15	2	4
158	1	6	1	6	320	1500	338	14	18	1278	1.00	15	2	4
159	1	6	1	7	338	1500	387	26	49	1882	1.00	15	2	4
160	1	6	1	8	387	1500	430	35	43	1226	1.00	15	2	4
161	2	6	1	1	0	1500	17	44	17	390	1.00	15	2	2
162	2	6	1	2	17	1500	23	14	6	404	1.00	15	2	2

ACOR MODERATOR ANALYSIS BY STREET/PROPERTY AS AT 1 TOR
GROU J SEPTEMBER TO AUGUST 8 TESTS: INCLUDING LAST

ref	REST 1 NO 2YES	GROUP	NO OF PROP	MONTH OF TEST	FIRST READING	PLOT SIZE m3	LAST READING	DURATION DAYS	CON'S m3	DAILY CON'S l/PROP/D	METER SPEC (m3/hr)	AGE-BASE 92 PROP YRS	MAIN YRS	0 ADUL
163	2	6	1	3	17	1500	30	28	13	469	1.00	15	2	2
164	2	6	1	4	30	1500	65	96	35	362	1.00	15	2	2
165	2	6	1	5	65	1500	80	46	15	331	1.00	15	2	2
166	2	6	1	6	80	1500	84	14	4	255	1.00	15	2	2
167	1	6	1	7	84	1500	90	26	7	255	1.00	15	2	2
168	1	6	1	8	90	1500	98	35	8	223	1.00	15	2	2
169	1	6	1	1	0	1500	21	44	21	484	1.00	15	2	2
170	1	6	1	2	21	1500	28	14	7	504	1.00	15	2	2
171	1	6	1	3	28	1500	43	28	15	525	1.00	15	2	2
172	1	6	1	4	43	1500	83	96	40	412	1.00	15	2	2
173	1	6	1	5	83	1500	99	46	16	355	1.00	15	2	2
174	1	6	1	6	99	1500	102	14	3	243	1.00	15	2	2
175	2	6	1	7	102	1500	113	26	10	393	1.00	15	2	2
176	2	6	1	8	113	1500	124	35	11	316	1.00	15	2	2
177	2	6	1	1	0	1500	15	44	15	348	1.00	15	2	2
178	2	6	1	2	15	1500	19	14	4	288	1.00	15	2	2
179	2	6	1	3	19	1500	28	28	8	292	1.00	15	2	2
180	2	6	1	4	28	1500	58	96	30	313	1.00	15	2	2
181	2	6	1	5	58	1500	78	46	21	447	1.00	15	2	2
182	2	6	1	6	78	1500	82	14	4	293	1.00	15	2	2
183	1	6	1	7	82	1500	107	26	25	942	1.00	15	2	2
184	1	6	1	8	107	1500	122	35	15	425	1.00	15	2	2
185	1	6	1	1	151	1500	178	44	27	604	1.00	15	2	2
186	1	6	1	2	178	1500	184	14	7	471	1.00	15	2	2
187	1	6	1	3	184	1500	196	28	12	439	1.00	15	2	2
188	1	6	1	4	196	1500	244	96	47	492	1.00	15	2	2
189	1	6	1	5	244	1500	266	46	23	490	1.00	15	2	2
190	1	6	1	6	266	1500	272	14	6	429	1.00	15	2	2
191	2	6	1	7	272	1500	291	26	18	709	1.00	15	2	2
192	2	6	1	8	291	1500	302	35	11	316	1.00	15	2	2
193	2	6	1	1	0	1500	1	44	1	17	1.00	15	2	1
194	2	6	1	2	1	1500	1	14	0	6	1.00	15	2	1
195	2	6	1	3	1	1500	1	28	0	6	1.00	15	2	1
196	2	6	1	4	1	1500	2	96	1	14	1.00	15	2	1
197	2	6	1	5	2	1500	11	46	9	198	1.00	15	2	1
198	2	6	1	6	11	1500	12	14	0	35	1.00	15	2	1
199	1	6	1	7	12	1500	26	26	14	533	1.00	15	2	1
200	1	6	1	8	26	1500	27	35	1	21	1.00	15	2	1
201	1	6	1	1	669	1500	699	44	30	691	2.50	15	2	2
202	1	6	1	2	699	1500	709	14	9	662	2.50	15	2	2
203	1	6	1	3	709	1500	729	28	21	734	2.50	15	2	2
204	1	6	1	4	729	1500	801	96	72	746	2.50	15	2	2
205	1	6	1	5	801	1500	849	46	48	1051	2.50	15	2	2
206	1	6	1	6	849	1500	860	14	11	808	2.50	15	2	2
207	2	6	1	7	860	1500	902	26	41	1595	2.50	15	2	2
208	2	6	1	8	902	1500	929	35	27	782	2.50	15	2	2
209	2	6	1	1	0	1500	21	44	21	471	1.00	15	2	2
210	2	6	1	2	21	1500	27	14	6	440	1.00	15	2	2
211	2	6	1	3	27	1500	44	28	17	604	1.00	15	2	2
212	2	6	1	4	44	1500	84	96	41	423	1.00	15	2	2
213	2	6	1	5	84	1500	130	46	45	987	1.00	15	2	2
214	2	6	1	6	130	1500	140	14	11	761	1.00	15	2	2
215	1	6	1	7	140	1500	168	26	28	1079	1.00	15	2	2
216	1	6	1	8	168	1500	192	35	24	672	1.00	15	2	2

GROUP J MODERATOR/HOUSEHOLD DATA TESTS 1991/1992

ACOR MODERATOR ANALYSIS BY STREET/PROPERTY AS AT 1 TOR
GROU J SEPTEMBER TO AUGUST 8 TESTS: INCLUDING LAST

ref	REST 1 NO 2YES	GROUP	NO OF PROP	MONTH OF TEST	FIRST READING	PLOT SIZE m3	LAST READING	DURATION DAYS	CON'S m3	DAILY CON'S l/PROP/D	METER SPEC (m3/hr)	AGE-BASE 92 PROP YRS	MAIN YRS	0 ADUL
217	1	6	1	1	0	1500	49	44	49	1108	1.00	15	2	3
218	1	6	1	2	49	1500	58	14	9	635	1.00	15	2	3
219	1	6	1	3	58	1500	79	28	22	780	1.00	15	2	3
220	1	6	1	4	79	1500	159	96	79	823	1.00	15	2	3
221	1	6	1	5	159	1500	195	46	36	788	1.00	15	2	3
222	1	6	1	6	195	1500	206	14	11	821	1.00	15	2	3
223	2	6	1	7	206	1500	246	26	40	1547	1.00	15	2	3
224	2	6	1	8	246	1500	270	35	24	676	1.00	15	2	3
225	2	6	1	1	0	1500	27	44	27	620	1.00	15	2	2
226	2	6	1	2	27	1500	34	14	7	495	1.00	15	2	2
227	2	6	1	3	34	1500	51	28	17	609	1.00	15	2	2
228	2	6	1	4	51	1500	115	96	64	662	1.00	15	2	2
229	2	6	1	5	115	1500	148	46	33	713	1.00	15	2	2
230	2	6	1	6	148	1500	156	14	8	573	1.00	15	2	2
231	1	6	1	7	156	1500	179	26	24	906	1.00	15	2	2
232	1	6	1	8	179	1500	196	35	17	491	1.00	15	2	2
233	1	6	1	1	113	1500	129	44	16	354	2.50	15	2	4
234	1	6	1	2	129	1500	134	14	5	373	2.50	15	2	4
235	1	6	1	3	134	1500	145	28	11	397	2.50	15	2	4
236	1	6	1	4	145	1500	180	96	35	367	2.50	15	2	4
237	1	6	1	5	180	1500	197	46	17	376	2.50	15	2	4
238	1	6	1	6	197	1500	201	13	4	298	2.50	15	2	4
239	2	6	1	7	201	1500	211	27	10	366	2.50	15	2	4
240	2	6	1	8	211	1500	223	35	12	339	2.50	15	2	4
241	2	6	1	1	152	1500	165	44	13	295	1.00	15	2	2
242	2	6	1	2	165	1500	170	14	5	339	1.00	15	2	2
243	2	6	1	3	170	1500	183	28	13	461	1.00	15	2	2
244	2	6	1	4	183	1500	218	96	36	370	1.00	15	2	2
245	2	6	1	5	218	1500	243	46	25	543	1.00	15	2	2
246	2	6	1	6	243	1500	248	13	5	375	1.00	15	2	2
247	1	6	1	7	248	1500	261	27	13	491	1.00	15	2	2
248	1	6	1	8	261	1500	276	35	15	421	1.00	15	2	2
249	2	6	1	1	0	1000	46	43	46	1060	1.00	40	2	2
250	2	6	1	2	46	1000	53	14	8	541	1.00	40	2	2
251	2	6	1	3	53	1000	67	28	14	503	1.00	40	2	2
252	2	6	1	4	67	1000	111	94	44	467	1.00	40	2	2
253	2	6	1	5	111	1000	148	47	37	784	1.00	40	2	2
254	2	6	1	6	148	1000	155	13	7	514	1.00	40	2	2
255	1	6	1	7	155	1000	197	31	42	1348	1.00	40	2	2
256	1	6	1	8	197	1000	219	32	23	707	1.00	40	2	2
257	2	6	1	1	0	1000	17	43	17	386	1.00	40	2	2
258	2	6	1	2	17	1000	21	14	4	297	1.00	40	2	2
259	2	6	1	3	21	1000	31	28	10	355	1.00	40	2	2
260	2	6	1	4	31	1000	62	94	31	329	1.00	40	2	2
261	2	6	1	5	62	1000	87	47	25	535	1.00	40	2	2
262	2	6	1	6	87	1000	92	13	5	355	1.00	40	2	2
263	1	6	1	7	92	1000	112	31	21	669	1.00	40	2	2
264	1	6	1	8	112	1000	124	32	12	372	1.00	40	2	2
265	1	6	1	1	0	1000	29	43	29	680	1.00	40	2	2
266	1	6	1	2	29	1000	39	14	9	669	1.00	40	2	2
267	1	6	1	3	39	1000	56	28	17	615	1.00	40	2	2
268	1	6	1	4	56	1000	94	94	39	410	1.00	40	2	2
269	1	6	1	5	94	1000	114	47	19	412	1.00	40	2	2
270	1	6	1	6	114	1000	117	13	3	220	1.00	40	2	2

ACOR MODERATOR ANALYSIS BY STREET/PROPERTY AS AT 1 TOR
GROU J SEPTEMBER TO AUGUST 8 TESTS: INCLUDING LAST

ref	REST 1 NO 2YRS	GROUPNO	OF PROP	MONTH OF TEST	FIRST READING	PLCT SIZE m3	LAST READING	DURATION DAYS	CON'S m3	DAILY CON'S l/PROP/D	METER SPEC (m3/hr)	AGE-BASE 92 PROP YRS	MAIN YRS	0 ADUL
271	2	6	1	7	117	1000	127	31	10	321	1.00	40	2	2
272	2	6	1	8	127	1000	136	32	10	298	1.00	40	2	2
273	2	6	1	1	0	1000	11	43	10	242	1.00	40	2	2
274	2	6	1	2	11	1000	13	14	2	176	1.00	40	2	2
275	2	6	1	3	13	1000	20	28	7	241	1.00	40	2	2
276	2	6	1	4	20	1000	37	94	17	184	1.00	40	2	2
277	2	6	1	5	37	1000	48	47	11	238	1.00	40	2	2
278	2	6	1	6	48	1000	50	13	2	170	1.00	40	2	2
279	1	6	1	7	50	1000	53	31	3	96	1.00	40	2	2
280	1	6	1	8	53	1000	63	32	10	300	1.00	40	2	2
281	1	6	1	1	0	1000	34	43	34	782	1.00	40	2	2
282	1	6	1	2	34	1000	43	14	9	647	1.00	40	2	2
283	1	6	1	3	43	1000	61	28	18	658	1.00	40	2	2
284	1	6	1	4	61	1000	116	94	55	580	1.00	40	2	2
285	1	6	1	5	116	1000	141	47	25	541	1.00	40	2	2
286	1	6	1	6	141	1000	149	13	8	587	1.00	40	2	2
287	2	6	1	7	149	1000	169	31	20	656	1.00	40	2	2
288	2	6	1	8	169	1000	180	32	11	342	1.00	40	2	2
289	1	6	1	1	62	1000	79	43	17	387	2.50	40	2	2
290	1	6	1	2	79	1000	83	14	4	294	2.50	40	2	2
291	1	6	1	3	83	1000	92	28	9	324	2.50	40	2	2
292	1	6	1	4	92	1000	103	94	10	110	2.50	40	2	2
293	1	6	1	5	103	1000	135	47	32	688	2.50	40	2	2
294	1	6	1	6	135	1000	139	13	4	297	2.50	40	2	2
295	2	6	1	7	139	1000	153	31	14	445	2.50	40	2	2
296	2	6	1	8	153	1000	163	32	10	322	2.50	40	2	2
297	2	6	1	1	0	1000	27	43	27	628	1.00	40	2	2
298	2	6	1	2	27	1000	34	14	7	518	1.00	40	2	2
299	2	6	1	3	34	1000	51	28	16	586	1.00	40	2	2
300	2	6	1	4	51	1000	119	94	68	726	1.00	40	2	2
301	2	6	1	5	119	1000	130	47	11	227	1.00	40	2	2
302	2	6	1	6	130	1000	136	13	6	459	1.00	40	2	2
303	2	6	1	7	136	1000	151	31	16	504	1.00	40	2	2
304	2	6	1	8	151	1000	167	32	16	497	1.00	40	2	2
305	2	6	1	1	0	1000	24	43	23	545	1.00	40	2	2
306	2	6	1	2	24	1000	32	14	9	634	1.00	40	2	2
307	2	6	1	3	32	1000	51	28	18	650	1.00	40	2	2
308	2	6	1	4	51	1000	114	94	63	671	1.00	40	2	2
309	2	6	1	5	114	1000	177	47	63	1348	1.00	40	2	2
310	2	6	1	6	177	1000	185	13	7	568	1.00	40	2	2
311	1	6	1	7	185	1000	225	31	41	1319	1.00	40	2	2
312	1	6	1	8	225	1000	242	32	17	518	1.00	40	2	2
313	1	6	1	1	0	1000	35	43	35	817	1.00	40	2	2
314	1	6	1	2	35	1000	44	14	8	586	1.00	40	2	2
315	1	6	1	3	44	1000	63	28	19	690	1.00	40	2	2
316	1	6	1	4	63	1000	112	94	49	518	1.00	40	2	2
317	1	6	1	5	112	1000	150	47	38	811	1.00	40	2	2
318	1	6	1	6	150	1000	157	13	8	592	1.00	40	2	2
319	2	6	1	7	157	1000	192	31	35	1115	1.00	40	2	2
320	2	6	1	8	192	1000	216	32	24	747	1.00	40	2	2

ACOR GROU ref	CCUPANCY T CHILD	TOTAL	STRRET PRESS mhead	FLOW HOUSE L/MIN	STREET	CUSTOMER AT HOME 1=NO
1	0	1	60	16	18	2
2	0	1	60	16	18	2
3	0	1	60	16	18	2
4	0	1	60	16	18	2
5	0	1	60	16	18	2
6	0	1	60	16	18	2
7	0	1	60	16	18	2
8	0	1	60	16	18	2
9	0	4	60	16	18	1
10	0	4	60	16	18	1
11	0	4	60	16	18	1
12	0	4	60	16	18	1
13	0	4	60	16	18	1
14	0	4	60	16	18	1
15	0	4	60	16	18	1
16	0	4	60	16	18	1
17	0	2	60	16	18	1
18	0	2	60	16	18	1
19	0	2	60	16	18	1
20	0	2	60	16	18	1
21	0	2	60	16	18	1
22	0	2	60	16	18	1
23	0	2	60	16	18	1
24	0	2	60	16	18	1
25	0	2	60	16	18	1
26	0	2	60	16	18	1
27	0	2	60	16	18	1
28	0	2	60	16	18	1
29	0	2	60	16	18	1
30	0	2	60	16	18	1
31	0	2	60	16	18	1
32	0	2	60	16	18	1
33	2	5	60	16	18	1
34	2	5	60	16	18	1
35	2	5	60	16	18	1
36	2	5	60	16	18	1
37	2	5	60	16	18	1
38	2	5	60	16	18	1
39	2	5	60	16	18	1
40	2	5	60	16	18	1
41	0	3	60	16	18	1
42	0	3	60	16	18	1
43	0	3	60	16	18	1
44	0	3	60	16	18	1
45	0	3	60	16	18	1
46	0	3	60	16	18	1
47	0	3	60	16	18	1
48	0	3	60	16	18	1
49	2	4	60	16	18	2
50	2	4	60	16	18	2
51	2	4	60	16	18	2
52	2	4	60	16	18	2
53	2	4	60	16	18	2
54	2	4	60	16	18	2

ACOR
GROU

ref	CCUPANCY T CHILD	TOTAL	STRRET PRESS mhead	FLOW HOUSE L/MIN	STREET	CUSTOMER AT HOME 1=NO
55	2	4	60	16	18	2
56	2	4	60	16	18	2
57	0	2	60	16	18	1
58	0	2	60	16	18	1
59	0	2	60	16	18	1
60	0	2	60	16	18	1
61	0	2	60	16	18	1
62	0	2	60	16	18	1
63	0	2	60	16	18	1
64	0	2	60	16	18	1
65	0	2	60	16	18	1
66	0	2	60	16	18	1
67	0	2	60	16	18	1
68	0	2	60	16	18	1
69	0	2	60	16	18	1
70	0	2	60	16	18	1
71	0	2	60	16	18	1
72	0	2	60	16	18	1
73	0	4	60	16	18	2
74	0	4	60	16	18	2
75	0	4	60	16	18	2
76	0	4	60	16	18	2
77	0	4	60	16	18	2
78	0	4	60	16	18	2
79	0	4	60	16	18	2
80	0	4	60	16	18	2
81	0	3	60	16	18	2
82	0	3	60	16	18	2
83	0	3	60	16	18	2
84	0	3	60	16	18	2
85	0	3	60	16	18	2
86	0	3	60	16	18	2
87	0	3	60	16	18	2
88	0	3	60	16	18	2
89	0	1	60	16	18	2
90	0	1	60	16	18	2
91	0	1	60	16	18	2
92	0	1	60	16	18	2
93	0	1	60	16	18	2
94	0	1	60	16	18	2
95	0	1	60	16	18	2
96	0	1	60	16	18	2
97	0	2	60	16	18	1
98	0	2	60	16	18	1
99	0	2	60	16	18	1
100	0	2	60	16	18	1
101	0	2	60	16	18	1
102	0	2	60	16	18	1
103	0	2	60	16	18	1
104	0	2	60	16	18	1
105	0	2				1
106	0	2				1
107	0	2				1
108	0	2				1

GROUP J MODERATOR/HOUSEHOLD DATA TESTS 1991/1992

ACOR
GROU
CCUPANCY STRRET FLOW CUSTOMER
T TOTALPRESS HOUSESTREET AT HOME
ref CHILD mhead L/MIN 1=NO

ref	CHILD	TOTAL	mhead	L/MIN	1=NO
109	0	2			1
110	0	2			1
111	0	2			1
112	0	2			1
113	2	4			1
114	2	4			1
115	2	4			1
116	2	4			1
117	2	4			1
118	2	4			1
119	2	4			1
120	2	4			1
121	0	2			1
122	0	2			1
123	0	2			1
124	0	2			1
125	0	2			1
126	0	2			1
127	0	2			1
128	0	2			1
129	0	2			1
130	0	2			1
131	0	2			1
132	0	2			1
133	0	2			1
134	0	2			1
135	0	2			1
136	0	2			1
137	0	2			1
138	0	2			1
139	0	2			1
140	0	2			1
141	0	2			1
142	0	2			1
143	0	2			1
144	0	2			1
145	0	2			1
146	0	2			1
147	0	2			1
148	0	2			1
149	0	2			1
150	0	2			1
151	0	2			1
152	0	2			1
153	3	7			2
154	3	7			2
155	3	7			2
156	3	7			2
157	3	7			2
158	3	7			2
159	3	7			2
160	3	7			2
161	2	4			1
162	2	4			1

ACOR
GROU
CCUPANCY STRRET FLOW CUSTOMER
T TOTALPRESS HOUSESTREET AT HOME
ref CHILD mhead L/MIN 1=NO

ref	CHILD	TOTAL	PRESS mhead	FLOW HOUSESTREET L/MIN	CUSTOMER AT HOME 1=NO	
163	2	4			1	
164	2	4			1	
165	2	4			1	
166	2	4			1	
167	2	4			1	
168	2	4			1	
169	1	3			1	
170	1	3			1	
171	1	3			1	
172	1	3			1	
173	1	3			1	
174	1	3			1	
175	1	3			1	
176	1	3			1	
177	0	2			2	
178	0	2			2	
179	0	2			2	
180	0	2			2	
181	0	2			2	
182	0	2			2	
183	0	2			2	
184	0	2			2	
185	0	2			1	
186	0	2			1	
187	0	2			1	
188	0	2			1	
189	0	2			1	
190	0	2			1	
191	0	2			1	
192	0	2			1	
193	0	1			1	granny flat
194	0	1			1	granny flat
195	0	1			1	granny flat
196	0	1			1	granny flat
197	0	1			1	granny flat
198	0	1			1	granny flat
199	0	1			1	granny flat
200	0	1			1	granny flat
201	3	5			1	
202	3	5			1	
203	3	5			1	
204	3	5			1	
205	3	5			1	
206	3	5			1	
207	3	5			1	
208	3	5			1	
209	0	2			1	
210	0	2			1	
211	0	2			1	
212	0	2			1	
213	0	2			1	
214	0	2			1	
215	0	2			1	
216	0	2			1	

ACOR GROU ref	CCUPANCY T CHILD	TOTAL	STREET PRESS mhead	FLOW HOUSE L/MIN	STREET	CUSTOMER AT HOME 1=NO
217	2	5				1
218	2	5				1
219	2	5				1
220	2	5				1
221	2	5				1
222	2	5				1
223	2	5				1
224	2	5				1
225	0	2				1
226	0	2				1
227	0	2				1
228	0	2				1
229	0	2				1
230	0	2				1
231	0	2				1
232	0	2				1
233	0	4				1
234	0	4				1
235	0	4				1
236	0	4				1
237	0	4				1
238	0	4				1
239	0	4				1
240	0	4				1
241	0	2				1
242	0	2				1
243	0	2				1
244	0	2				1
245	0	2				1
246	0	2				1
247	0	2				1
248	0	2				1
249	1	3				1
250	1	3				1
251	1	3				1
252	1	3				1
253	1	3				1
254	1	3				1
255	1	3				1
256	1	3				1
257	1	3				2
258	1	3				2
259	1	3				2
260	1	3				2
261	1	3				2
262	1	3				2
263	1	3				2
264	1	3				2
265	0	2				2
266	0	2				2
267	0	2				2
268	0	2				2
269	0	2				2
270	0	2				2

ACOR
GROU
CCUPANCY STRRET FLOW CUSTOMER
T TOTALPRESS HOUSESTREET AT HOME
ref CHILD mhead L/MIN 1=NO

ref	CHILD	TOTAL	STRRET PRESS mhead	FLOW HOUSESTREET L/MIN	CUSTOMER AT HOME 1=NO
271	0	2			2
272	0	2			2
273	0	2			1
274	0	2			1
275	0	2			1
276	0	2			1
277	0	2			1
278	0	2			1
279	0	2			1
280	0	2			1
281	2	4			1
282	2	4			1
283	2	4			1
284	2	4			1
285	2	4			1
286	2	4			1
287	2	4			1
288	2	4			1
289	0	2			2
290	0	2			2
291	0	2			2
292	0	2			2
293	0	2			2
294	0	2			2
295	0	2			2
296	0	2			2
297	0	2			1
298	0	2			1
299	0	2			1
300	0	2			1
301	0	2			1
302	0	2			1
303	0	2			1
304	0	2			1
305	0	2			1
306	0	2			1
307	0	2			1
308	0	2			1
309	0	2			1
310	0	2			1
311	0	2			1
312	0	2			1
313	3	5			2
314	3	5			2
315	3	5			2
316	3	5			2
317	3	5			2
318	3	5			2
319	3	5			2
320	3	5			2

PHASE 2: HOUSEHOLD CUSTOMERS PAYING BY METER

PAC MARCH1994
FILE REVVALUE
SAVED AS VALUES ONLY WITH DATE AND READING REMOVED
COMBINED SLIM FILE OR REVTESTA (FIRST 492CASES) AND REVTESTB (SECOND100 CASES)

REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S l/PROP/D
2049999	0	0	27	2	0	1	0	0	0	0	0	0	526	207	394
1460759	0	0	1		0	1	0	0	0	0	0	0	528	169	320
1460758	0	0	1		0	1	0	0	0	0	0	0	528	202	383
1460757	0	0	1		0	1	0	0	0	0	0	1	528	93	176
1460756	0	0	1	3	0	1	0	0	0	0	0	1	531	152	286
1460755	0	0	1		0	1	0	0	0	0	0	0	524	160	305
1460753	0	0	1		0	1	0	0	0	0	0	0	531	155	292
1460741	0	0	10	2	0	1	0	0	0	0	0	1	536	233	435
1460671	0	0	1	2	0	1	0	0	0	0	0	1	535	94	176
1460643	0	0	1		0	1	0	0	0	0	0	0	531	155	292
1460641	0	0	1		0	1	0	0	0	0	0	1	531	62	117
1460633	0	0	1	2	0	1	0	0	0	0	0	0	530	123	232
1460632	0	0	1	2	0	1	0	0	0	0	0	0	530	102	192
1460628	0	0	1	2	0	1	0	0	0	0	0	0	530	258	487
1460627	0	0	1		0	1	0	0	0	0	0	0	531	247	465
1460626	0	0	1		0	1	0	0	0	0	0	1	530	192	362
1460623	0	0	1	3	0	1	0	0	0	0	0	1	531	118	222
1460622	0	0	1	4	0	1	0	0	0	0	0	0	531	207	390
1460619	0	0	1		0	1	0	0	0	0	0	0	531	231	435
1460604	0	0	1	3	0	1	0	0	0	0	0	1	531	169	318
1460526	0	0	1		0	1	0	0	0	0	0	1	528	89	169
1460524	0	0	1	2	0	1	0	0	0	0	0	0	531	152	286
1460522	0	0	1		0	1	0	0	0	0	0	0	528	217	411
1460520	1	0	1	2	0	1	0	0	0	0	0	1	449	51	114
1460519	0	0	1		0	1	0	0	0	0	0	0	530	141	266
1460516	0	0	1		0	1	0	0	0	0	0	0	531	274	516
1460502	0	0	1	3	0	1	0	0	0	0	0	0	530	155	292
1460466	0	0	1	3	0	1	0	0	0	0	0	0	531	238	448
1460415	0	0	1	3	0	1	0	0	0	0	0	0	437	209	478
1460389	0	0	1	2	0	1	0	0	0	0	0	1	441	82	186
1460388	0	0	1	3	0	1	0	0	0	0	0	0	530	201	379
1460361	0	0	1	2	0	1	0	0	0	0	0	1	531	183	345
1460346	0	0	1	2	0	1	0	0	0	0	0	1	496	166	335
1460345	0	0	1	2	0	1	0	0	0	0	0	0	474	163	344
1460343	0	0	1	5	0	1	0	0	0	0	0	0	539	308	571
1460342	0	0	1	2	0	1	0	0	0	0	0	1	507	122	241
1460341	0	0	1	2	0	1	0	0	0	0	0	1	524	127	242
1460339	0	0	1	2	0	1	0	0	0	0	0	0	535	211	394
1460321	0	0	1	2	0	1	0	0	0	0	0	0	530	276	521
1460319	0	0	1	3	0	1	0	0	0	0	0	0	531	153	288
1460318	0	0	1	3	0	1	0	0	0	0	0	0	531	382	719
1460309	0	0	1	4	0	1	0	0	0	0	0	0	417	139	333
1460308	0	0	1		0	1	0	0	0	0	0	0	442	144	326
1460304	0	0	1		0	1	0	0	0	0	0	0	530	207	391
1460259	0	0	1		0	1	0	0	0	0	0	0	468	191	408
1460211	0	0	20	2	0	1	0	0	0	0	0	0	438	105	240
1460201	0	0	20		0	1	0	0	0	0	0	0	464	345	744
1460196	0	0	1	2	0	1	0	0	0	0	0	0	530	151	285
1460188	0	0	1		0	1	0	0	0	0	0	0	530	257	485
1460187	0	0	1	3	0	1	0	0	0	0	0	0	530	317	598
1460177	0	0	1		0	1	0	0	0	0	0	1	531	69	130
1460175	0	0	1		0	1	0	0	0	0	0	0	531	170	320
1460174	0	0	1	2	0	1	0	0	0	0	0	0	531	221	416
1460171	0	0	1		0	1	0	0	0	0	0	0	531	194	365
1460167	0	0	1		0	1	0	0	0	0	0	0	531	138	260
1460159	0	0	1		0	1	0	0	0	0	0	0	531	170	320
1460158	0	0	1		0	1	0	0	0	0	0	0	531	107	202
1460156	0	0	1	2	0	1	0	0	0	0	0	1	531	66	124
1460154	0	0	1	3	0	1	0	0	0	0	0	0	531	244	460
1460153	0	0	1	5	0	1	0	0	0	0	0	0	531	267	503
1460142	0	0	1	2	0	1	0	0	0	0	0	1	531	196	369
1460140	0	0	10	3	0	1	0	0	0	0	0	1	535	136	254
1460138	0	0	1		0	1	0	0	0	0	0	1	530	176	332
1460134	0	0	1		0	1	0	0	0	0	0	0	530	214	404
1460133	0	0	1		0	1	0	0	0	0	0	0	530	112	211
1460132	0	0	1		0	1	0	0	0	0	0	1	530	152	287
1460131	0	0	1	3	0	1	0	0	0	0	0	0	532	277	521
1460123	0	0	1	2	0	1	0	0	0	0	0	0	528	261	494
1460121	0	0	1	2	0	1	0	0	0	0	0	0	531	266	501

PAC MARCH1994
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PHASE 2: HOUSEHOLD CUSTOMERS PAYING BY METER

REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S l/PROP/D
1460115	0	0	1	5	0	1	0	0	0	0	0	0	467	206	441
1460111	0	0	1	3	0	1	0	0	0	0	0	0	530	157	296
1460109	0	0	1	2	0	1	0	0	0	0	0	1	530	32	60
1460106	0	0	1	3	0	1	0	0	0	0	0	0	530	83	157
1460101	0	1			0							0	185	115	622
1460089	0	0	1		0	1	0	0	0	0	0	1	530	144	272
1460088	0	0	1		0	1	0	0	0	0	0	0	529	93	176
1460081	0	0	1		0	1	0	0	0	0	0	0	530	150	283
1460076	0	0	1	2	0	1	0	0	0	0	0	0	531	146	275
1460074	0	0	1		0	1	0	0	0	0	0	0	531	420	791
1460072	0	0	1	2	0	1	0	0	0	0	0	1	465	212	456
1460068	0	0	1	3	0	1	0	0	0	0	0	0	530	194	366
1460066	0	0	1	2	0	1	0	0	0	0	0	0	530	138	260
1460064	0	0	1	3	0	1	0	0	0	0	0	0	531	262	493
1460063	0	0	20		0	0	0	0	0	0	1	0	532	311	585
1460059	0	0	1	4	0	1	0	0	0	0	0	1	531	185	348
1460054	0	0	1		0	1	0	0	0	0	0	0	530	130	245
1460051	0	0	1	2	0	1	0	0	0	0	0	1	463	175	378
1460049	0	0	1		0	1	0	0	0	0	0	1	531	193	363
1460047	0	0	1		0	1	0	0	0	0	0	1	467	113	242
1460046	0	0	1		0	1	0	0	0	0	0	1	467	165	353
1460042	0	0	1	4	0	1	0	0	0	0	0	0	531	156	294
1460037	0	0	1	4	1	1	0	0	0	0	0	0	531	375	706
1460029	0	0	1	2	0	1	0	0	0	0	0	1	531	138	260
1460028	0	0	1		0	1	0	0	0	0	0	0	531	88	166
1460027	0	0	1		0	1	0	0	0	0	0	0	531	166	313
1460013	0	0	1		0	1	0	0	0	0	0	0	530	166	313
1460012	0	0	1		0	1	0	0	0	0	0	0	530	132	249
1460009	0	0	1		0	1	0	0	0	0	0	1	462	122	264
1460008	0	0	1		0	1	0	0	0	0	0	0	530	377	711
1460005	0	1	1		0	1	0	0	0	0	0	0	469	130	277
1440661	1	0			0							0	529	103	195
1430457	0	0	2	5	0	1	0	0	0	0	0	0	571	295	517
1430455	0	0	2		0	1	0	0	0	0	0	0	563	204	362
1430454	0	0			0							0	372	142	382
1430453	0	0			0							0	408	85	208
1430452	0	0			0							0	255	129	506
1430451	0	0			0							0	256	84	328
1430450	0	0	2		0	1	0	0	0	0	0	1	422	64	152
1430449	0	0	2		0	1	0	0	0	0	0	0	421	117	278
1430448	0	0	2		0	1	0	0	0	0	0	0	530	148	279
1430447	0	0	2		0	1	0	0	0	0	0	0	421	134	318
1430446	0	0	2		0	1	0	0	0	0	0	0	487	156	320
1430045	0	0	3	3	0	1	0	0	0	0	0	0	421	97	230
1430037	0	0	3	4	0	1	0	0	0	0	0	0	607	292	481
1430036	0	0	3	2	0	1	0	0	0	0	0	0	607	140	231
1430033	0	0	3	4	0	1	0	0	0	0	0	0	607	302	498
1430032	0	0	3	4	0	1	0	0	0	0	0	0	607	259	427
1430031	0	0	3	3	0	1	0	0	0	0	0	0	607	168	277
1430029	0	0	3		0	1	0	0	0	0	0	0	607	305	502
1430024	0	0	3		0	1	0	0	0	0	0	0	538	134	249
1400521	0	0	15	5	0	0	0	0	0	0	1	0	346	187	540
1400213	0	0	5	2	0	0	0	0	0	0	1	0	425	112	264
1400210	0	0			0							0	458	240	524
1400107	0	0			0							0	358	137	383
1400098	0	0	12	3	0	0	0	0	0	0	1	0	525	287	547
1400084	0	0	40	2	0	0	0	0	0	0	1	0	417	136	326
1400083	0	0	3	3	0	0	0	0	0	0	1	0	412	240	583
1400082	0	0	15	1	0	0	0	0	0	0	1	0	525	214	408
1400049	0	0			0	0	0	0	0	0	1	0	582	352	605
1400044	0	1	27	1	0	0	0	0	0	0	1	0	526	256	487
1400042	0	1	27	3	0	0	0	0	0	0	1	0	526	233	443
1400021	0	0			0							0	455	127	279
1400006	0	0			0							0	458	115	251
1400001	0	0	7	2	0	0	0	0	0	0	1	0	526	221	420
1391111	0	0	3	2	0	0	0	1	0	0	0	1	522	134	257
1390511	0	0	3	2	0	0	0	1	0	0	0	1	598	156	261
1390196	0	0	3	2	0	0	0	1	0	0	0	1	522	109	209
1390070	0	0	3	3	0	0	0	1	0	0	0	1	522	135	259

PAC MARCH1994
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PHASE 2: HOUSEHOLD CUSTOMERS PAYING BY METER

REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S I/PROP/I
1390013	0	0	3	2	0	0	0	1	0	0	0	1	522	131	251
1360681	0	0	3	4	0	1	0	0	0	0	0	0	522	169	324
1360672	0	0	3	3	0	1	0	0	0	0	0	0	522	153	293
1360648	0	0	3		0	1	0	0	0	0	0	0	420	238	567
1360647	0	0	3		0	1	0	0	0	0	0	1	369	72	195
1360582	0	0			0	1	0	0	0	0	0	0	530	127	240
1360548	0	0	3		0	1	0	0	0	0	0	0	412	86	209
1360531	0	0	3		0	1	0	0	0	0	0	0	519	106	204
1360530	0	0	3		0	1	0	0	0	0	0	0	518	227	438
1360529	0	0	3		0	1	0	0	0	0	0	0	519	109	210
1360527	0	0	3		0	1	0	0	0	0	0	0	519	110	212
1360518	0	0			0							1	210	73	348
1360517	0	0			0							0	193	93	482
1360453	0	0	3	2	0	1	0	0	0	0	0	0	519	119	229
1360450	0	0	3		0	1	0	0	0	0	0	0	420	106	252
1360427	0	0	3		0	1	0	0	0	0	0	0	522	137	262
1360426	0	0			0							0	195	85	436
1360424	0	0			0							0	267	87	326
1360421	0	0	3	4	0	1	0	0	0	0	0	0	519	130	250
1360411	0	0	3	2	0	1	0	0	0	0	0	0	519	57	110
1360403	0	0	3		0	1	0	0	0	0	0	0	519	207	399
1360367	0	0	3	3	0	1	0	0	0	0	0	0	518	107	207
1360342	0	0	3	2	0	1	0	0	0	0	0	0	519	212	408
1360341	0	0	3	3	0	1	0	0	0	0	0	0	519	192	370
1360277	0	0	3	4	0	1	0	0	0	0	0	0	412	173	420
1360276	0	0	3	3	0	1	0	0	0	0	0	0	519	159	306
1360195	0	0	3	3	0	1	0	0	0	0	0	0	518	237	458
1360194	0	0	2	4	0	1	0	0	0	0	0	0	518	208	402
1360192	0	0	3	3	0							0	519	146	281
1360191	0	0	3		0	1	0	0	0	0	0	0	519	216	416
1360190	0	0	3	4	0	1	0	0	0	0	0	0	452	174	385
1360189	0	0	3	3	0	1	0	0	0	0	0	0	519	163	314
1360188	0	0	3	4	0	1	0	0	0	0	0	0	519	175	337
1360187	0	0	3	3	0	1	0	0	0	0	0	0	519	131	252
1360186	0	0	3	3	0	1	0	0	0	0	0	0	519	126	243
1360185	0	0	3	5	0	1	0	0	0	0	0	0	519	243	468
1360184	0	0	3	4	0	1	0	0	0	0	0	0	519	226	435
1360183	0	0	3	4	0	1	0	0	0	0	0	0	519	249	480
1360182	0	0	3		0							0	412	215	522
1360178	0	0	3		0	1	0	0	0	0	0	0	519	156	301
1360177	0	0	3		0	1	0	0	0	0	0	0	519	219	422
1360176	0	0	3		0	1	0	0	0	0	0	0	412	140	340
1360175	0	0	3		0	1	0	0	0	0	0	0	519	102	197
1360172	0	0	3		0	1	0	0	0	0	0	0	519	188	362
1360164	0	0	3		0	1	0	0	0	0	0	0	518	244	471
1360163	0	0	2	2	0	1	0	0	0	0	0	0	518	167	322
1360159	0	0	3	2	0	1	0	0	0	0	0	0	519	152	293
1360158	0	0	3	2	0	1	0	0	0	0	0	0	519	103	198
1360157	0	0	3	2	0	1	0	0	0	0	0	0	519	223	430
1360156	0	0	3	3	0	1	0	0	0	0	0	0	519	234	451
1360155	0	0	3		0	1	0	0	0	0	0	0	256	155	605
1360154	0	0	3	2	0	1	0	0	0	0	0	0	410	127	310
1360153	0	0	3	4	0	1	0	0	0	0	0	0	518	183	353
1360151	0	0	2	4	0	1	0	0	0	0	0	0	518	157	303
1360149	0	0	3	3	0	1	0	0	0	0	0	0	519	185	356
1360148	0	0	3	4	0	1	0	0	0	0	0	0	421	145	344
1360145	0	0	3	3	0	1	0	0	0	0	0	0	522	141	270
1360137	0	0	3	2	0	1	0	0	0	0	0	0	519	130	250
1360136	0	0	3	3	0	1	0	0	0	0	0	0	519	185	356
1360132	0	0	3		0	1	0	0	0	0	0	0	521	132	253
1360130	0	0	3		0	1	0	0	0	0	0	0	326	75	230
1360129	0	0	3		0	1	0	0	0	0	0	0	521	80	154
1360127	0	0	3	2	0	1	0	0	0	0	0	0	521	140	269
1360125	0	0	3		0	1	0	0	0	0	0	0	522	227	435
1360121	0	0	4	3	0	0	0	1	0	0	0	0	521	190	365
1360118	0	0	3		0	1	0	0	0	0	0	0	522	210	402
1360117	0	0	3		0	1	0	0	0	0	0	0	522	144	276
1360114	0	0	3	4	0	1	0	0	0	0	0	0	521	172	330
1360113	0	0	3	2	0	1	0	0	0	0	0	0	521	160	307

APPENDIX H

PAC MARCH1994
FILE REVVALUE
SAVED AS VALUES ONLY WITH DATE AND READING REMOVED
COMBINED SLIM FILE OR REVTESTA (FIRST 492CASES) AND REVTESTB (SECOND100 CASES)

PHASE 2: HOUSEHOLD CUSTOMERS PAYING BY METER

REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S I/PROP/
1360109	0	0	4	4	0	1	0	0	0	0	0	0	472	255	540
1360108	0	0	2	3	0	1	0	0	0	0	0	0	518	248	479
1360107	0	0	3	3	0	1	0	0	0	0	0	0	518	220	425
1360103	0	0	3		0	1	0	0	0	0	0	0	518	194	375
1360093	0	0	3	6	0	1	0	0	0	0	0	0	522	262	502
1360092	0	0	3	4	0	1	0	0	0	0	0	0	522	201	385
1360091	0	0	3		0	1	0	0	0	0	0	0	522	202	387
1360089	0	0	3		0	1	0	0	0	0	0	0	522	158	303
1360088	0	0	3	4	0	1	0	0	0	0	0	0	522	203	389
1360079	0	0	4	3	0	1	0	0	0	0	0	0	521	152	292
1360078	0	0	4	3	0	0	0	0	1	0	0	0	333	76	228
1360073	0	0	3	4	0	1	0	0	0	0	0	0	416	237	570
1360072	0	0	3	2	0	1	0	0	0	0	0	0	521	138	265
1360071	0	0	3	4	0	1	0	0	0	0	0	0	412	154	374
1331238	0	0			0							0	331	193	583
1330501	0	0			0	1	0	0	0	0	0	0	368	323	878
1330014	0	0	3	1	0	0	0	1	0	0	0	0	523	70	134
1330009	0	0	3	1	0	0	0	1	0	0	0	0	523	61	117
1330008	0	0	3	1	0	0	0	1	0	0	0	0	523	83	159
1320547	0	0	3		0	0	0	1	0	0	0	0	622	115	185
1320546	0	0	3		0	0	0	1	0	0	0	0	622	193	310
1320408	0	0			0							0	461	121	262
1320406	0	0	3	2	0	0	0	1	0	0	0	0	626	233	372
1320405	0	0	3	1	0	0	0	1	0	0	0	0	626	100	160
1320401	0	0	3	2	0	0	0	1	0	0	0	1	444	52	117
1320005	0	0	2	2	0	0	0	1	0	0	0	0	694	89	128
1318102	0	0	3	1	0	0	0	1	0	0	0	0	520	38	73
1318101	0	0	3	2	0	0	0	1	0	0	0	0	520	118	227
1318100	0	0	3		0	0	0	1	0	0	0	0	520	246	473
1311163	0	0	3		0	0	0	1	0	0	0	0	622	146	235
1311162	0	0	3		0	0	0	1	0	0	0	0	603	198	328
1310898	0	0	3		0	0	0	1	0	0	0	0	520	82	158
1310896	0	0	3	2	0	0	0	1	0	0	0	0	520	166	319
1310895	0	0	3	1	0	0	0	1	0	0	0	0	520	139	267
1310806	0	0	2	2	0	0	0	1	0	0	0	0	525	109	208
1310801	0	0	2	2	0	0	0	1	0	0	0	0	525	142	270
1310381	0	0	3		0	0	0	1	0	0	0	0	564	254	450
1310312	0	0	3		0	0	0	1	0	0	0	0	520	177	340
1310311	0	0			0							0	357	139	389
1310304	0	0	3	3	0	0	0	1	0	0	0	0	520	153	294
1310303	0	0	3	4	0	0	0	1	0	0	0	0	520	377	725
1310197	0	0	3	5	0	0	0	1	0	0	0	0	525	156	297
1310181	0	0	3		0	0	0	1	0	0	0	0	520	49	94
1310169	0	0			0	0	0	0	0	0	0	0	357	73	204
1310168	0	0	3		0	0	0	1	0	0	0	0	520	102	196
1310164	0	0	3		0	0	0	1	0	0	0	0	520	157	302
1310163	0	0	3		0	0	0	1	0	0	0	0	520	134	258
1310161	0	0			1							0	358	572	1598
1310091	0	0			0							0	357	101	283
1310032	0	0	3		0	0	0	1	0	0	0	0	520	96	185
1310031	0	0	3		0	0	0	1	0	0	0	0	520	76	146
1310028	0	0	3	3	0	0	0	1	0	0	0	0	520	191	367
1310027	0	0	3	2	0	0	0	1	0	0	0	0	520	149	287
1310019	0	0	3	2	0	0	0	1	0	0	0	0	520	135	260
1300671	0	0	2	2	0	0	0	1	0	0	0	0	793	151	190
1280114	0	0	27	2	0	1	0	0	0	0	0	0	347	138	398
1280111	0	0	27	5	0	1	0	0	0	0	0	0	346	158	457
1280109	0	0	27		0	1	0	0	0	0	0	0	346	149	431
1280106	0	0	37		0	1	0	0	0	0	0	0	346	110	318
1280103	0	0	27		0	1	0	0	0	0	0	0	346	134	387
1280102	0	0	27	3	0	1	0	0	0	0	0	0	346	59	171
1280101	0	0	27		0	1	0	0	0	0	0	0	346	69	199
1280100	0	0	37	4	0	1	0	0	0	0	0	0	346	107	309
1280099	0	0	27	5	0	1	0	0	0	0	0	0	346	163	471
1280098	0	0	27		0	1	0	0	0	0	0	0	346	93	269
1280097	0	0	27	3	0	1	0	0	0	0	0	0	346	60	173
1280096	0	0	27	3	0	1	0	0	0	0	0	0	346	137	396
1280095	0	0	27	3	0	1	0	0	0	0	0	0	346	120	347
1280094	0	0	27	4	0	1	0	0	0	0	0	0	346	108	312

PAC MARCH1994
FILE REVVALUE
SAVED AS VALUES ONLY WITH DATE AND READING REMOVED
COMBINED SLIM FILE OR REVTESTA (FIRST 492CASES) AND REVTESTB (SECOND100 CASES)

PHASE 2: HOUSEHOLD CUSTOMERS PAYING BY METER

REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S l/PROP/
1280093	0	0	27	2	0	1	0	0	0	0	0	0	346	81	234
1280092	0	0	27	5	0	1	0	0	0	0	0	0	346	105	303
1280091	0	0	27	4	0	1	0	0	0	0	0	0	346	161	465
1280090	0	0	27		0	1	0	0	0	0	0	0	346	140	405
1280089	0	0	27	2	0	1	0	0	0	0	0	0	347	88	254
1280088	0	0	27	4	0	1	0	0	0	0	0	0	350	155	443
1280087	0	0	27	2	0	1	0	0	0	0	0	0	346	166	480
1280086	0	0	27	2	0	1	0	0	0	0	0	0	347	96	277
1280085	0	0	27	2	0	1	0	0	0	0	0	0	346	83	240
1280084	0	0	27	2	0	1	0	0	0	0	0	0	346	103	298
1280083	0	0	27	4	0	1	0	0	0	0	0	0	433	49	113
1280082	0	0	27	3	0	1	0	0	0	0	0	0	346	117	338
1280080	0	0	27	4	0	1	0	0	0	0	0	0	346	136	393
1280079	0	0	27	2	0	1	0	0	0	0	0	0	238	67	282
1280077	0	0	27	4	0	1	0	0	0	0	0	0	346	135	390
1280076	0	0	27	3	0	1	0	0	0	0	0	0	347	147	424
1280075	0	0	27	2	0	1	0	0	0	0	0	0	346	62	179
1280073	0	0	27		0	1	0	0	0	0	0	0	528	190	360
1280072	0	0	27	3	0	1	0	0	0	0	0	0	346	98	283
1280071	0	0	27	3	0	1	0	0	0	0	0	0	346	140	405
1280070	0	0	27	2	0	1	0	0	0	0	0	0	528	184	348
1280069	0	0			0							1	120	22	183
1280068	0	0			0							1	202	19	94
1280065	0	0	27	5	0	1	0	0	0	0	0	0	346	240	694
1280064	0	0	27		0	1	0	0	0	0	0	0	346	77	223
1280063	0	0	27		0	1	0	0	0	0	0	0	346	133	384
1280062	0	0	27	2	0	1	0	0	0	0	0	0	346	66	191
1280061	0	0	37	2	0	1	0	0	0	0	0	0	528	130	246
1280060	0	0	37		0	1	0	0	0	0	0	0	528	138	261
1280051	0	0	37	4	0	1	0	0	0	0	0	0	528	230	436
1280050	0	0	37	3	0	1	0	0	0	0	0	0	528	157	297
1280049	0	0	37	4	0	1	0	0	0	0	0	0	528	232	439
1280047	0	0	37	4	0	1	0	0	0	0	0	0	528	255	483
1280046	0	0	27		0	1	0	0	0	0	0	0	528	194	367
1280045	0	0	37	4	0	1	0	0	0	0	0	0	528	185	350
1280044	0	0	37	3	0	1	0	0	0	0	0	0	528	163	309
1280043	0	0	37	4	0	1	0	0	0	0	0	0	528	225	426
1280040	0	0	37	4	0	1	0	0	0	0	0	0	528	115	218
1280039	0	0	27	4	0	1	0	0	0	0	0	0	528	204	386
1280038	0	0	27	2	0	1	0	0	0	0	0	0	528	162	307
1280037	0	0	37	4	0	1	0	0	0	0	0	0	528	182	345
1280035	0	0	37	2	0	1	0	0	0	0	0	0	459	129	281
1280034	0	0	37	5	0	1	0	0	0	0	0	0	529	222	420
1280032	0	0	27		0	1	0	0	0	0	0	0	528	189	358
1280028	0	0	27		0	1	0	0	0	0	0	0	528	138	261
1280027	0	0	27		0	1	0	0	0	0	0	0	528	148	280
1280026	0	0	37		0	1	0	0	0	0	0	0	528	296	561
1280025	0	0	37		0	1	0	0	0	0	0	0	528	164	311
1280024	0	0	37		0	1	0	0	0	0	0	0	528	125	237
1280020	0	0	27	4	0	1	0	0	0	0	0	0	528	185	350
1280019	0	0	27	2	0	1	0	0	0	0	0	0	528	136	258
1280016	0	0	27	4	0	1	0	0	0	0	0	0	714	252	353
1280014	0	0	27	1	0	1	0	0	0	0	0	0	528	163	309
1280013	0	0	27	5	0	1	0	0	0	0	0	0	528	219	415
1280010	0	0	37	4	0	1	0	0	0	0	0	0	529	246	465
1280009	0	0	37	4	0	1	0	0	0	0	0	0	421	187	444
1280008	0	0	37		0	1	0	0	0	0	0	0	528	154	292
1280007	0	0	37		0	1	0	0	0	0	0	0	528	139	263
1280006	0	0	37		0	1	0	0	0	0	0	0	528	147	278
1280005	0	0	37		0	1	0	0	0	0	0	0	528	164	311
1280004	0	0	37	1	0	1	0	0	0	0	0	0	528	33	63
1280003	0	0	37	3	0	1	0	0	0	0	0	0	529	166	314
1280002	0	0	37	4	0	1	0	0	0	0	0	0	529	232	439
1280001	0	0	37	3	0	1	0	0	0	0	0	0	528	173	328
1260359	1	0			0							0	481	98	204
1260033	0	0	17		0	1	0	0	0	0	0	0	431	129	299
1260031	0	0	17	3	0	1	0	0	0	0	0	0	536	255	476
1260029	0	0			0							0	363	177	488
1260014	0	0			0							0	467	51	109

PHASE 2: HOUSEHOLD CUSTOMERS PAYING BY METER

PAC MARCH1994
FILE REVVALUE
SAVED AS VALUES ONLY WITH DATE AND READING REMOVED
COMBINED SLIM FILE OR REVTESTA (FIRST 492CASES) AND REVTESTB (SECOND100 CASES)

REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S l/PROP/D
1260006	0	0	2		0	1	0	0	0	0	0	0	532	143	269
1260002	0	0	10	3	0	1	0	0	0	0	0	0	709	484	683
1240172	0	0	37	2	0	0	0	0	1	0	0	0	528	106	201
1240171	0	0	3	2	0	0	0	0	1	0	0	0	528	124	235
1240031	1	0	17		0							0	468	8	17
1240029	0	0	3	2	0	0	0	0	1	0	0	0	528	114	216
1240028	0	0	3	1	0	0	0	0	1	0	0	0	528	133	252
1240009	0	0	17	2	0	1	0	0	0	0	0	0	573	70	122
1240001	0	0	67	2	0	0	1	0	0	0	0	0	532	139	261
1230680	0	1			0							0	372	72	194
1230623	0	0	37	1	0	0	0	0	1	0	0	0	454	34	75
1230170	0	0	57	3	0	0	0	0	0	0	1	0	518	228	440
1230091	0	0			0							0	376	144	383
1230049	0	0	57	4	0	0	0	0	0	0	1	0	337	52	154
1230021	0	0	17		0	0	0	0	0	0	1	0	518	106	205
1230009	0	0	57	2	0	0	0	0	0	0	1	0	518	248	479
1230005	0	0			0							0	454	157	346
1230004	0	0	37	1	0	0	0	0	0	0	1	0	708	108	153
1220646	0	0			0							0	450	113	251
1220645	0	1			0							0	659	154	234
1220615	0	0	20	3	0	1	0	0	0	0	0	0	518	190	367
1220245	0	1	32	1	0	1	0	0	0	0	0	0	735	84	114
1220221	0	0	27	2	0	1	0	0	0	0	0	0	450	390	867
1220101	0	1			0							0	371	94	253
1220039	0	1	17	2	0	0	0	0	0	0	1	0	519	167	322
1220021	0	0	2	3	0	1	0	0	0	0	0	0	518	187	361
1220016	0	0			0							0	450	145	322
1220011	0	0			0							0	450	162	360
1220010	0	0	27	3	0	1	0	0	0	0	0	0	519	306	590
1220003	0	0			0							0	450	246	547
1210114	0	0	17	4	0	1	0	0	0	0	0	0	388	102	263
1210112	0	0	17	3	0	1	0	0	0	0	0	0	348	111	319
1210108	0	0	17		0	1	0	0	0	0	0	0	428	175	409
1210106	0	0	17		0	1	0	0	0	0	0	0	433	129	298
1210104	0				0							0	376	170	452
1210084	0	0	17		0	1	0	0	0	0	0	0	427	116	272
1210083	0	0	17		0	1	0	0	0	0	0	0	427	105	246
1210077	0	0	17	2	0	1	0	0	0	0	0	0	439	85	194
1210076	0	0	17	1	0	1	0	0	0	0	0	0	419	73	174
1210072	0	0	17		0	1	0	0	0	0	0	0	466	121	260
1210066	0	0	17		0	1	0	0	0	0	0	0	336	76	226
1210062	0	0	17		0	1	0	0	0	0	0	0	424	191	450
1210056	0	0	17		0	1	0	0	0	0	0	0	391	86	220
1210055	0	0	17	2	0	1	0	0	0	0	0	0	440	83	189
1210051	0	0	17	5	0	1	0	0	0	0	0	0	427	191	447
1210050	0	0	17		0	1	0	0	0	0	0	0	445	87	196
1210049	0	0	17		0	1	0	0	0	0	0	0	500	77	154
1210048	0	0	17	2	0	1	0	0	0	0	0	0	500	128	256
1210047	0	0	17	1	0	1	0	0	0	0	0	0	500	57	114
1210045	0	0	17		0	1	0	0	0	0	0	0	500	156	312
1210044	0	0	17	2	0	1	0	0	0	0	0	0	500	94	188
1210043	0	0	17	1	0	1	0	0	0	0	0	0	539	30	56
1210042	0	0	17	1	0	1	0	0	0	0	0	0	423	73	173
1210040	0	0	17	2	0	1	0	0	0	0	0	0	423	56	132
1210039	0	0	17	2	0	1	0	0	0	0	0	0	437	70	160
1210038	0	0	17	1	0	1	0	0	0	0	0	0	423	69	163
1210037	0	0	17	2	0	1	0	0	0	0	0	0	423	82	194
1210036	0	0	17	1	0	1	0	0	0	0	0	0	433	47	109
1210035	1	0	17		0	1	0	0	0	0	0	0	336	20	60
1210034	0	0	17		0	1	0	0	0	0	0	0	424	139	328
1210033	0	0	17		0	1	0	0	0	0	0	0	335	38	113
1210032	0	0	17		0	1	0	0	0	0	0	0	424	78	184
1210031	0	0	17		0	1	0	0	0	0	0	0	424	82	193
1210030	1	0	17		0							0	424	45	106
1210029	0	0	14		0	1	0	0	0	0	0	0	424	49	116
1210028	0	0	14		0	1	0	0	0	0	0	0	424	135	318
1210026	0	0	14		0							0	424	48	113
1210025	0	0	17	2	0	1	0	0	0	0	0	0	426	177	415
1210024	1	0	17	2	0	1	0	0	0	0	0	0	426	33	77

PHASE 2: HOUSEHOLD CUSTOMERS PAYING BY METER

PAC MARCH1994
FILE REVVALUE
SAVED AS VALUES ONLY WITH DATE AND READING REMOVED
COMBINED SLIM FILE OR REVTESTA (FIRST 492CASES) AND REVTESTB (SECOND100 CASES)

REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S l/PROP/D
1210023	0	0	17		0	1	0	0	0	0	0	0	426	118	277
1210022	0	0	17		0	1	0	0	0	0	0	0	592	106	179
1210021	0	0			0							0	464	120	259
1210020	0	0	17		0	1	0	0	0	0	0	0	528	110	208
1210019	0	0	17		0	1	0	0	0	0	0	0	528	136	258
1210018	0	0	17	4	0	1	0	0	0	0	0	0	528	182	345
1210017	0	0	17	2	0	1	0	0	0	0	0	0	462	175	379
1210012	0	0	37	2	0	0	0	0	1	0	0	0	528	123	233
1210011	0	0	37	3	0	0	0	0	1	0	0	0	528	100	189
1210009	0	0	37	2	0	0	0	0	1	0	0	0	528	111	210
1210008	0	0	3	2	0	0	0	0	1	0	0	0	528	177	335
1210007	0	0	3	4	0	0	0	0	1	0	0	0	528	224	424
1210006	0	0	37	3	0	0	0	0	1	0	0	0	528	212	402
1210004	0	0	37	1	0	0	0	0	1	0	0	0	462	49	106
1210003	0	0	3	1	0	0	0	0	1	0	0	0	462	145	314
1210002	0	0	3	1	0	0	0	0	1	0	0	0	528	225	426
1210001	0	0	3	1	0	0	0	0	1	0	0	0	528	75	142
1180589	0	0	37	2	0	0	0	0	0	0	1	0	533	142	266
1180316	0	1			0							0	462	175	379
1180003	0	0			0							0	646	225	348
1170420	0	0	27	2	0	0	0	0	0	0	1	0	528	155	294
1170185	0	0	67	5	0	0	0	0	0	0	1	0	530	379	715
1170159	0	0	27	2	0	1	0	0	0	0	0	0	518	164	317
1170150	0	1	27	2	0	1	0	0	0	0	0	0	532	201	378
1170132	0	0			0							0	460	217	472
1170115	0	0	47	2	0	1	0	0	0	0	0	0	430	229	533
1170100	1	0	17		0	0	0	0	0	0	1	0	426	23	54
1170092	0	0	27	2	0	1	0	0	0	0	0	0	505	146	289
1170032	0	0	67	5	0	0	0	0	0	0	1	0	530	197	372
1170027	0	0	67	3	0	1	0	0	0	0	0	0	346	163	471
1160067	0	0			0							0	374	26	70
1160066	0	0			0							0	374	111	297
1160062	0	0			0							0	557	158	284
1160059	0	0	80		0	0	1	0	0	0	0	0	623	421	676
1159999	0	0	1		0	0	0	1	0	0	0	1	572	165	288
1159971	0	0	1	5	0	0	0	1	0	0	0	1	586	261	445
1159906	0	0	1		0	0	0	1	0	0	0	1	652	195	299
1150779	0	0	3	2	0	0	0	1	0	0	0	1	427	38	89
1150668	0	0	3	1	0	0	0	1	0	0	0	1	519	78	150
1150667	0	0	3	2	0	0	0	1	0	0	0	1	695	104	150
1150666	0	0	3	3	0	0	0	1	0	0	0	1	519	130	250
1150665	0	0			0							1	353	35	99
1150662	0	0	3		0	0	0	1	0	0	0	0	519	161	310
1150516	0	0	2	2	0	0	0	1	0	0	0	0	332	170	512
1150478	0	0	4	3	0	0	0	1	0	0	0	0	519	170	328
1150476	0	0	4	4	0	0	0	1	0	0	0	0	519	221	426
1150425	0	0	3	2	0	0	0	1	0	0	0	1	519	147	283
1150296	0	0	3		0	0	0	1	0	0	0	1	519	109	210
1150294	0	0	3	2	0	0	0	1	0	0	0	1	519	132	254
1150292	0	0	3	3	0	0	0	1	0	0	0	1	519	141	272
1150291	0	0	3		0	0	0	1	0	0	0	1	520	153	294
1150272	0	0	1		0	0	0	1	0	0	0	1	519	195	376
1150271	1	0	1		0	0	0	1	0	0	0	1	434	39	90
1150248	0	0	1	2	0	0	0	1	0	0	0	1	519	131	252
1150247	0	0			0							0	353	47	133
1150227	0	0	2	2	0	0	0	1	0	0	0	0	520	135	260
1150226	0	0	2	3	0	0	0	1	0	0	0	0	520	242	465
1150224	0	0	2	1	0	0	0	1	0	0	0	0	520	70	135
1150223	0	0	3		0							0	519	225	434
1150222	0	0	2	2	0	1	0	0	0	0	0	1	519	62	119
1150157	1	0	2	1	0	0	0	1	0	0	0	1	517	20	39
1150156	0	0	2	2	0	0	0	1	0	0	0	1	517	103	199
1150105	0	0	1		0	0	0	1	0	0	0	1	581	158	272
1150103	0	0			0							0	353	105	297
1150096	0	0	1		0	0	0	1	0	0	0	1	519	125	241
1150094	0	0	3	2	0	0	0	1	0	0	0	1	519	63	121
1150093	0	0	3	1	0	0	0	1	0	0	0	1	519	38	73
1150092	0	0	3	2	0	0	0	1	0	0	0	1	519	98	189
1150091	0	0	3	1	0	0	0	1	0	0	0	1	519	53	102

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REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S l/PROP/D
1150090	0	0	3	2	0							0	353	66	187
1150088	0	0	3	1	0	0	0	1	0	0	0	1	519	87	168
1150087	0	0	3	1	0	0	0	1	0	0	0	1	519	51	98
1150086	0	0	3	2	0	0	0	1	0	0	0	1	519	48	92
1150083	0	0	3	1	0	0	0	1	0	0	0	1	519	43	83
1150082	0	0	3	1	0	0	0	1	0	0	0	1	519	97	187
1150081	0	0	3	2	0	0	0	1	0	0	0	1	335	37	110
1150076	0	0	3	1	0	0	0	1	0	0	0	1	519	47	91
1150074	1	0	3	2	0	0	0	1	0	0	0	1	425	14	33
1150071	0	0	3	1	0	0	0	1	0	0	0	1	519	77	148
1120593	1	1	29	1	0	0	0	0	0	0	1	1	518	43	83
1120115	0				0							1	175	72	411
1120105	0				0							0	356	105	295
1110038	0	0	5	4	0	1	0	0	0	0	0	1	475	161	339
1109983	0	0	2		0	1	0	0	0	0	0	1	521	180	345
1109982	0	0	2		0	1	0	0	0	0	0	0	521	294	564
1109937	0	0	1		0	1	0	0	0	0	0	1	420	132	314
1109936	0	0	1		0	1	0	0	0	0	0	0	521	254	488
1109932	0	0	7		0	1	0	0	0	0	0	0	525	101	192
1109931	0	0	7		0	1	0	0	0	0	0	0	525	133	253
1109929	0				0							0	372	113	304
1109928	0	0	7		0	1	0	0	0	0	0	0	525	96	183
1109927	0	0	7		0	1	0	0	0	0	0	1	525	92	175
1108202	0	0	7	3	0	0	0	0	0	0	1	1	525	146	278
1108201	0		7	4	0	0	0	0	0	0	1	0	525	334	636
1108001	0	0	1	3	0	1	0	0	0	0	0	0	519	227	437
1101262	0	0	1		0	1	0	0	0	0	0	0	519	101	195
1101261	0	0	1		0	1	0	0	0	0	0	0	519	166	320
1101158	0	0	3	3	0	0	0	0	0	0	1	0	521	266	511
1101118	0	0	1		0	1	0	0	0	0	0	0	526	267	508
1101111	1	0	20		0	0	1	0	0	0	0	1	528	198	375
1101068	0	0	7	3	0	1	0	0	0	0	0	0	523	113	216
1101044	0	0	7	3	0	1	0	0	0	0	0	1	523	220	421
1101029	0	0	3	2	0	1	0	0	0	0	0	1	526	57	108
1101023	0	0	1	2	0	1	0	0	0	0	0	0	526	182	346
1101021	0	0	1	3	0	1	0	0	0	0	0	0	522	122	234
1100928	0	0	1		0	1	0	0	0	0	0	0	521	71	136
1100893	0	0	2	2	0	0	0	0	0	0	1	1	506	165	326
1100573	0	0	1		0	1	0	0	0	0	0	0	521	58	111
1100572	0	0	1	3	0							1	521	144	276
1100571	0	0	1	3	0							0	521	199	382
1100540	0				0							0	374	384	1027
1100389	0	0	1		0	1	0	0	0	0	0	0	521	92	177
1100388	0	0	1	2	0	1	0	0	0	0	0	0	521	165	317
1100387	0				0							0	376	129	343
1100386	0	0	1		0	1	0	0	0	0	0	0	521	136	261
1100331	0	0	1		0	1	0	0	0	0	0	0	521	150	288
1100239	0	0	1	3	0	1	0	0	0	0	0	0	502	238	474
1100238	0	0	20	2	0	1	0	0	0	0	0	1	522	138	264
1100177	0	0	5	4	0	1	0	0	0	0	0	1	525	203	387
1100176	0	0	5	3	0	1	0	0	0	0	0	0	525	239	455
1100127	0	0	2	4	0	1	0	0	0	0	0	0	521	166	319
1100126	0	0	1		0	1	0	0	0	0	0	0	426	111	261
1100124	0	0	2		0	1	0	0	0	0	0	0	521	161	309
1100114	0	0	1		0	1	0	0	0	0	0	0	601	205	341
1100108	0	0	1		0	1	0	0	0	0	0	0	614	244	397
1100107	0	0	1		0	1	0	0	0	0	0	0	521	182	349
1100104	0	0	1		0	1	0	0	0	0	0	0	519	109	210
1100099	0	0	1		0	1	0	0	0	0	0	0	521	188	361
1100098	0	0	1		0	1	0	0	0	0	0	0	522	94	180
1100094	0	0	1	3	0	1	0	0	0	0	0	0	519	155	299
1100086	1	0	1		0	1	0	0	0	0	0	0	521	178	342
1100078	0	0	2		0	1	0	0	0	0	0	0	521	146	280
1100076	0	0	2		0	1	0	0	0	0	0	0	521	132	253
1100074	0				0							1	374	70	187
1100072	0	0	1		0	1	0	0	0	0	0	0	519	113	218
1100071	0	0	1		0	1	0	0	0	0	0	0	519	120	231
1100069	0	0	2	3	0	1	0	0	0	0	0	0	619	343	554
1100059	0	0	1	2	0	1	0	0	0	0	0	0	521	98	188

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REF	VOID 1=YES	INT. 1=INT	AGE YRS	NO. OCCS.	SPLY LKGE	ACORN "B"	ACORN "C"	ACORN "E"	ACORN "F"	ACORN "G"	ACORN "J"	MOD.	DAYS	CON'S m3	CON'S l/PROP/D
1100014	0	0	1	2	0	1	0	0	0	0	0	0	522	149	285
1090355	0	0	1	2	0	0	0	0	0	0	1	1	519	179	345
1090354	0	0	1	2	0	0	0	0	0	0	1	0	519	75	145
1090061	0	1	20	2	0	0	0	0	0	0	1	0	713	141	198
1088894	0	0	4	6	0	0	0	1	0	0	0	0	532	231	434
1088893	0	0	4	5	0	0	0	1	0	0	0	0	532	295	555
1088892	0	0	4	6	0	0	0	1	0	0	0	0	533	315	591
1088891	0	0	4	4	0	0	0	1	0	0	0	0	533	385	722
1088890	0	0	4	3	0	0	0	1	0	0	0	0	533	452	848
1080668	0	0	3	7	0	0	0	1	0	0	0	0	525	131	250
1080333	0	0	2		0	0	0	1	0	0	0	0	533	346	649
1080249	0	0	2	6	0	0	0	1	0	0	0	0	533	149	280
1080248	0	0	2	4	0	0	0	1	0	0	0	0	364	144	396
1080247	0	0	2	5	0	0	0	1	0	0	0	0	533	401	752
1080246	0	0	3	9	0	0	0	1	0	0	0	0	533	404	758
1080195	0	0	3	1	0	0	0	1	0	0	0	1	536	58	108
1080185	0	0	3	2	0	0	0	1	0	0	0	0	536	157	293
1080161	0	0	4	5	0	0	0	1	0	0	0	0	536	474	884
1080159	0	0	4	3	0	0	0	1	0	0	0	0	536	271	506
1080156	0	0	4		0	0	0	1	0	0	0	0	536	391	729
1080143	0	0	2		0	0	0	1	0	0	0	1	536	163	304
1080121	0	0	3	7	0	0	0	1	0	0	0	0	536	607	1132
1080110	0	0	90	5	0	0	0	1	0	0	0	0	715	433	606
1080108	0				0							0	367	119	324
1080106	0				0							0	367	112	305
1080075	0	0	2		0	0	0	1	0	0	0	1	536	74	138
1080068	0	0	90	9	0	1	0	0	0	0	0	0	424	305	719
1080066	0	0	3		0	0	0	1	0	0	0	0	536	290	541
1080065	0	0	2		0	0	0	1	0	0	0	1	348	55	158
1051076	0	0	2	3	0	1	0	0	0	0	0	0	528	159	301
1051075	0	0	2	4	0	1	0	0	0	0	0	0	518	358	691
1051074	0	0	2	2	0	1	0	0	0	0	0	0	528	146	277
1051071	0	0	2	2	0	1	0	0	0	0	0	1	528	110	208
1050921	0	0	2	2	0	1	0	0	0	0	0	1	528	101	191
1050916	0	0	2	2	0	1	0	0	0	0	0	0	528	116	220
1050852	0	0	2	2	0	1	0	0	0	0	0	0	528	194	367
1050851	0	0	2	2	0	1	0	0	0	0	0	0	528	76	144
1050849	0	0	2	2	0	1	0	0	0	0	0	0	528	191	362
1050802	0				0							0	370	98	265
1050749	0	0	2	2	0	1	0	0	0	0	0	1	528	146	277
1050123	0	0	2	2	0	1	0	0	0	0	0	1	528	112	212
1030867	0	0	37		0							0	452	139	308
1030229	0	1	27	1	0	1	0	0	0	0	0	0	523	83	159
1030195	0	0	27	4	0	1	0	0	0	0	0	0	523	299	572
1030025	0				0							0	452	110	243
1030007	0	0	37		0	1	0	0	0	0	0	0	523	452	864
1029972	0	0	3		0	0	0	0	0	0	1	1	536	267	498
NR. PROP'S PER GROUP					2	383	3	100	17	0	31	101			

AVERAGE CONSUMPTION LTRS/PROP/DAY 325.633

PHASE 2 HOUSEHOLD SAMPLE (SURVEY OF 553 HOUSES)
ACORN ANALYSIS BY STREET/PROPERTY
PHASE 2 GROUPS B,C,E,F,G & J 31/03/93 - 22/09/93

REF	REST 1 NO 2 YES	GROUP	NO OF PROP	DAILY CON'S L/CON/D	DAILY CON'S L/PROP/D	DAILY CON'S L/HEAD/D	OCCUPANCY ADULT	OCCUPANCY CHILD	OCCUPANCY TOTAL	LEAK	VOID	SHARE	MODEL 11 L/PROP/DAY	MODEL 14 PLUS SHARE ALLOW OF -180(V) L/PROP/DAY	MODEL 14 L/PROP/DAY
1	1	0	1	149	149	149	1	0	1	0	0	0	288	221	221
2	1	0	1	224	224	112	2	0	2	0	0	0	312	290	290
3	1	0	1	374	374	94	2	2	4	0	0	0	360	428	428
4	1	0	1	418	418	209	2	0	2	0	0	0	312	290	290
5	1	0	1	415	415	208	2	0	2	0	0	0	312	290	290
6	1	0	1	571	571	143	1	3	4	0	0	0	360	428	428
7	1	0	1	517	517	129	2	2	4	0	0	0	360	428	428
8	1	0	1	755	755	126	2	4	6	0	0	0	408	566	566
9	1	0	1	647	647	129	3	2	5	0	0	0	384	497	497
10	1	0	1	279	279	279	1	0	1	0	0	0	288	221	221
11	1	0	1	133	133	133	1	0	1	0	0	0	288	221	221
12	1	0	1	840	840	420	2	0	2	0	0	0	312	290	290
13	1	0	1	45	45	ERR	0	0	0	0	1	0	-8	14	14
14	1	0	1	245	245	123	2	0	2	0	0	0	312	290	290
15	1	0	1	250	250	125	2	0	2	0	0	0	312	290	290
16	1	0	1	270	270	135	2	0	2	0	0	0	312	290	290
17	1	0	1	333	333	111	2	1	3	0	0	0	336	359	359
18	1	0	1	666	666	222	3	0	3	0	0	0	336	359	359
19	1	0	1	48	48	ERR	0	0	0	0	1	0	-8	14	14
20	1	0	1	118	118	118	1	0	1	0	0	0	288	221	221
21	1	0	1	171	171	86	2	0	2	0	0	0	312	290	290
22	1	0	1	190	190	190	1	0	1	0	0	0	288	221	221
23	1	0	1	2539	2539	635	2	2	4	0	0	0	360	428	428
24	1	0	2	8910	4455	810	11	0	11	1	0	1	1873	1009	1189
25	1	0	1	525	525	131	2	2	4	0	0	0	360	428	428
26	1	0	2	1013	506	113	9	0	9	0	1	1	28	455	635
27	1	0	2	2161	1081	180	12	0	12	0	0	1	372	800	980
28	1	0	3	3856	1285	771	5	0	5	1	0	1	1729	595	775
29	1	0	1	305	305	305	1	0	1	0	0	0	288	221	221
30	1	0	3	1566	522	142	11	0	11	0	0	1	348	731	911
31	1	0	3	2152	717	135	16	0	16	0	0	1	468	1076	1256
32	1	0	4	1647	412	165	10	0	10	0	0	1	324	662	842
33	1	0	4	2364	591	215	11	0	11	0	0	1	348	731	911
34	1	0	4	997	249	83	12	0	12	0	0	1	372	800	980
35	1	0	4	1830	457	203	9	0	9	0	0	1	300	593	773
36	1	0	4	1735	434	108	16	0	16	0	0	1	468	1076	1256
37	1	0	4	1148	287	88	13	0	13	0	0	1	396	869	1049
38	1	0	4	1227	307	123	10	0	10	0	0	1	324	662	842
39	1	0	2	140	70	70	2	0	2	0	1	1	-140	-28	152
40	1	0	4	1309	327	187	7	0	7	0	0	1	252	455	635
41	1	0	4	935	234	78	12	0	12	0	0	1	372	800	980
42	1	0	2	684	342	86	8	0	8	0	0	1	276	524	704
43	1	0	4	1583	396	93	17	0	17	0	0	1	492	1145	1325
44	1	0	3	1323	441	110	12	0	12	0	0	1	372	800	980
45	1	0	2	383	192	128	3	0	3	0	0	1	156	179	359
46	1	0	2	1065	532	177	6	0	6	0	0	1	228	386	566
47	1	0	2	569	284	114	5	0	5	0	0	1	204	317	497
48	1	0	2	688	344	172	4	0	4	0	0	1	180	248	428
49	1	0	3	1682	561	210	8	0	8	0	0	1	276	524	704
50	1	0	4	1496	374	214	7	0	7	0	0	1	252	455	635
51	1	0	4	1512	378	168	9	0	9	0	0	1	300	593	773
52	1	0	4	1625	406	135	12	0	12	0	0	1	372	800	980
53	1	0	4	2341	585	180	13	0	13	0	0	1	396	869	1049
54	1	0	2	936	468	234	4	0	4	0	0	1	180	248	428
55	1	0	1	381	381	381	1	0	1	0	0	0	288	221	221
56	1	0	4	1909	477	159	12	0	12	0	0	1	372	800	980
57	1	0	4	2065	516	206	10	0	10	0	0	1	324	662	842
58	1	0	4	1362	341	195	7	0	7	0	0	1	252	455	635
59	1	0	4	1732	433	217	8	0	8	0	0	1	276	524	704

PHASE 2 HOUSEHOLD SAMPLE (SURVEY OF 553 HOUSES)
ACORN ANALYSIS BY STREET/PROPERTY
PHASE 2 GROUPS B,C,E,F,G & J 31/03/93 - 22/09/93

REF	REST 1 NO 2YES	GROUP	NO OF PROP	DAILY CON'S l/CON/D	DAILY CON'S l/PROP/D	DAILY CON'S l/HEAD/D	OCCUPANCY ADULT	CHILD	TOTAL	LEAK	VOID	SHARE	MODEL 11 L/PROP/DAY	MODEL 14 PLUS SHARE ALLOW OF -180(V) L/PROP/DAY	MODEL 14 L/PROP/DAY
60	1	0	2	991	496	248	4	0	4	0	0	1	180	248	428
61	1	0	3	1092	364	121	9	0	9	0	0	1	300	593	773
62	1	0	1	440	440	220	2	0	2	0	0	0	312	290	290
63	1	0	3	1519	506	117	13	0	13	0	0	1	396	869	1049
64	1	0	1	452	452	226	2	0	2	0	0	0	312	290	290
65	1	0	4	1623	406	180	9	0	9	0	0	1	300	593	773
66	1	0	4	1441	360	144	10	0	10	0	1	1	52	524	704
67	1	0	4	1134	283	113	10	0	10	0	0	1	324	662	842
68	1	0	1	716	716	179	4	0	4	0	0	0	360	428	428
69	1	0	1	98	98	98	1	0	1	0	0	0	288	221	221
70	1	0	1	845	845	169	5	0	5	0	0	0	384	497	497
71	1	0	1	358	358	119	3	0	3	0	0	0	336	359	359
72	1	0	4	809	202	116	7	0	7	0	0	1	252	455	635
73	1	0	4	1304	326	130	10	0	10	0	0	1	324	662	842
74	1	0	4	930	232	116	8	0	8	0	0	1	276	524	704
75	1	0	4	1886	472	126	15	0	15	0	0	1	444	1007	1187
76	1	0	3	1903	634	238	8	0	8	0	0	1	276	524	704
77	1	0	4	638	159	106	6	0	6	0	0	1	228	386	566
78	1	0	4	3415	854	342	10	0	10	0	0	1	324	662	842
79	1	0	4	968	242	88	11	0	11	0	0	1	348	731	911
80	1	1	1	334	334	167	2	0	2	0	0	0	529	290	290
81	1	1	1	318	318	159	2	0	2	0	0	0	529	290	290
82	1	1	1	280	280	140	2	0	2	0	0	0	529	290	290
83	1	1	1	174	174	58	3	0	3	0	0	0	553	359	359
84	1	1	1	411	411	206	2	0	2	0	0	0	529	290	290
85	1	1	1	623	623	156	2	2	4	0	0	0	577	428	428
86	1	1	1	393	393	131	3	0	3	0	0	0	553	359	359
87	1	1	1	428	428	214	2	0	2	0	0	0	529	290	290
88	1	1	1	480	480	160	3	0	3	0	0	0	553	359	359
89	1	1	1	857	857	286	2	1	3	0	0	0	553	359	359
90	1	1	1	771	771	386	2	0	2	0	0	0	529	290	290
	90		201	1055	AVG 488	0			6	2	5	47	AVG 361	AVG 475	AVG 569
					MAX 4455								MAX 1873	MAX 1145	MAX 1325
					MIN 45								MIN -140	MIN -28	MIN 14

........MODEL 1................. FINANCIAL APPRAISAL OF FLOW MODERATOR

MODEL 1: INSTALLATION TO NEW PROPERTY IN BOUNDARY BOX FITTED FOR METERING.

NOTES 1) COST ITEM (7) @ £1
2)5000 NEW SMALL DIAMETER CONNECTION PER YEAR.
3)5000*40 LITRE/PROP/DAY SAVING = 0.2 MI/YR
4)COST OF CAPITAL 8%
5)CAPITAL AND ANNUAL OPERATING SAVINGS AS ANNUALISED
INCOME STREAM £290000 PER 5MI/DAY/YEAR=£58000/MI/DAY/YR

CASH FLOW FORECAST YEAR———>	0	1	2	3	4	5	6	7	8	9	10
COSTS											
MODERATOR INSTALATION 5000*£1	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
BENEFITS											
CAP/REV@£58K*0.2 MI/D											
FIRST YEAR	0	11600	11600	11600	11600	11600	11600	11600	11600	11600	11600
SECOND YEAR	0	0	11600	11600	11600	11600	11600	11600	11600	11600	11600
THIRD YEAR	0	0	0	11600	11600	11600	11600	11600	11600	11600	11600
FOURTH YEAR	0	0	0	0	11600	11600	11600	11600	11600	11600	11600
FIFTH YEAR	0	0	0	0	0	11600	11600	11600	11600	11600	11600
SIXTH YEAR	0	0	0	0	0	0	11600	11600	11600	11600	11600
SEVENTH YEAR	0	0	0	0	0	0	0	11600	11600	11600	11600
EIGHTH YEAR	0	0	0	0	0	0	0	0	11600	11600	11600
NINTH YEAR	0	0	0	0	0	0	0	0	0	11600	11600
TENTH YEAR	0	0	0	0	0	0	0	0	0	0	11600
BENEFITS - COSTS	-5000	6600	18200	29800	41400	53000	64600	64600	64600	64600	64600
DISCOUNT FACTOR	1	0.925926	0.857339	0.793832	0.73503	0.680583	0.63017	0.58349	0.540269	0.500249	0.463193
DISCOUNTED CAS FLOW	-5000	6111.111	15603.57	23656.2	30430.24	36070.91	40708.96	37693.48	34901.37	32316.08	29922.3
NPV	282414.2										
PAYBACK	1.4 YEARS										

Appendix J

FINANCIAL APPRAISAL OF FLOW MODERATOR

MODEL 2: INSTALLATION TO NEW PROPERTY IN BOUNDARY BOX AT FULL EXTRA COST.

NOTES 1)COST ITEM (2) @£30
3)5000 MAINTENANCE REPLACEMENTS/YR
4)5000*40 LITRE/PROP/DAY SAVING = 0.2 Ml/YR
5)COST OF CAPITAL 8%
6)CAPITAL AND ANNUAL OPERATING SAVINGS AS ANNUALISED
INCOME STREAM £290000 PER 5Ml/DAY/YEAR=£58000/Ml/DAY/YR

CASH FLOW FORECAST YEAR———>	0	1	2	3	4	5	6	7	8	9	10
COSTS											
MODERATOR INSTALATION 5000*£30	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000
BENEFITS											
CAP/REV@£58K*0.2 Ml/D											
FIRST YEAR	0	11600	11600	11600	11600	11600	11600	11600	11600	11600	11600
SECOND YEAR	0	0	11600	11600	11600	11600	11600	11600	11600	11600	11600
THIRD YEAR	0	0	0	11600	11600	11600	11600	11600	11600	11600	11600
FOURTH YEAR	0	0	0	0	11600	11600	11600	11600	11600	11600	11600
FIFTH YEAR	0	0	0	0	0	11600	11600	11600	11600	11600	11600
SIXTH YEAR	0	0	0	0	0	0	11600	11600	11600	11600	11600
SEVENTH YEAR	0	0	0	0	0	0	0	11600	11600	11600	11600
EIGHTH YEAR	0	0	0	0	0	0	0	0	11600	11600	11600
NINTH YEAR	0	0	0	0	0	0	0	0	0	11600	11600
TENTH YEAR	0	0	0	0	0	0	0	0	0	0	11600
BENEFITS - COSTS	-150000	-138400	-126800	-115200	-103600	-92000	-80400	-80400	-80400	-80400	-80400
DISCOUNT FACTOR	1	0.925926	0.857339	0.793832	0.73503	0.680583	0.63017	0.58349	0.540269	0.500249	0.463193
DISCOUNTED CAS FLOW	-150000	-128148	-108711	-91449.5	-76149.1	-62613.7	-50665.6	-46912.6	-43437.6	-40220	-37240.8
NPV	-835548										
PAYBACK	NA										

Appendix J

........MODEL 3.................   FINANCIAL APPRAISAL OF FLOW MODERATOR

MODEL 3: INSTALLATION TO EXISTING PROPERTY IN EXISTING STOP-TAPS (REQUIRING REPLACEMENT) OF INTERNAL TO HOUSEHOLDS

NOTES 1) COST ITEM (6) @ £6
2)5000 MODIFIED SMALL DIAMETER CONNECTION PER YEAR.
3)5000*40 LITRE/PROP/DAY SAVING = 0.2 Ml/YR
4)COST OF CAPITAL 8%
5)CAPITAL AND ANNUAL OPERATING SAVINGS AS ANNUALISED
INCOME STREAM £290000 PER 5Ml/DAY/YEAR=£58000/Ml/DAY/YR

CASH FLOW FORECAST YEAR———>	0	1	2	3	4	5	6	7	8	9	10
COSTS											
MODERATOR INSTALATION 5000*£6	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
BENEFITS											
CAP/REV@£58K*0.2 Ml/D											
FIRST YEAR	0	11600	11600	11600	11600	11600	11600	11600	11600	11600	11600
SECOND YEAR	0	0	11600	11600	11600	11600	11600	11600	11600	11600	11600
THIRD YEAR	0	0	0	11600	11600	11600	11600	11600	11600	11600	11600
FOURTH YEAR	0	0	0	0	11600	11600	11600	11600	11600	11600	11600
FIFTH YEAR	0	0	0	0	0	11600	11600	11600	11600	11600	11600
SIXTH YEAR	0	0	0	0	0	0	11600	11600	11600	11600	11600
SEVENTH YEAR	0	0	0	0	0	0	0	11600	11600	11600	11600
EIGHTH YEAR	0	0	0	0	0	0	0	0	11600	11600	11600
NINTH YEAR	0	0	0	0	0	0	0	0	0	11600	11600
TENTH YEAR	0	0	0	0	0	0	0	0	0	0	11600
BENEFITS - COSTS	-30000	-18400	-6800	4800	16400	28000	39600	39600	39600	39600	39600
DISCOUNT FACTOR	1	0.925926	0.857339	0.793832	0.73503	0.680583	0.63017	0.58349	0.540269	0.500249	0.463193
DISCOUNTED CAS FLOW	-30000	-17037	-5829.9	3810.395	12054.49	19056.33	24954.72	23106.22	21394.65	19809.86	18342.46
NPV	89662.18										
PAYBACK	3 YEARS										

Appendix J