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Water Services: Financial, Engineering and Scientific Planning

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SYMPOSIUM ON WATER SERVICES: FINANCIAL, ENGINEERING AND SCIENTIFIC PLANNING

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PREFACE

The main subject of study for the Symposium is the interface between possible economic and financial policies in water services; and desirable, or essential, scientific and engineering policies. On the scientific and engineering side there is the problem of setting priorities when not all can be done. On the financial and economic side there is the question whether modified or new solutions are desirable. Some of the latter are discussed in the National Water Council's document "Paying for Water".

Between the two approaches lies an area that could usefully be studied. It concerns such problems as whether financial and economic objectives accurately reflect engineering and scientific realities; or whether engineering and scientific techniques and planning methods could be developed more to take into account financial and economic influences.

The papers will reflect differing points of view about these problems which are the concern of all types of water authorities, whether in the United Kingdom or overseas.

WATER SERVICES: FINANCIAL, ENGINEERING AND SCIENTIFIC PLANNING

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1. PROBLEMS FACING UK WATER AUTHORITIES: THE PLANNING VIEW

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Water industry book assets, income and numbers of employees are briefly compared with other industries. Demands for action by the water industry arising from maintenance and renewal, improved standards and new and existing growth are analysed and approximately quantified. Problems of priority, influences on demand and the size/shape of the resultant multi £m investment and spending programmes are discussed in order to set out the planning framework of the Water Industry in England and Wales.

INTRODUCTION

Water in the quantities generally used of over 100 tonnes per household annually is heavy stuff and because it is in almost continuous use, piping it into and out of premises rather than supplying it on carts or in containers has been found the most efficient approach since Roman times at least. The result is a fixed system of high capital and lowish running costs and the industry is amongst the most capital intensive. The following figures some from the NEDO report on Nationalized Industries (ref 1) illustrate the point, and are worth pursuing in that report in greater depth.

TABLE 1 - Comparative Industrial Statistics

1975 Figures	Water (England and Wales) (1975)	British Gas (1975)	Electricity UK (1975)	ICI (1975)	Courtaulds (1975)	Shell (1976)
Fixed Assets (NBV) £ (m)	2552	1468	5199	1425	478	5350
Income £ (m) pa	632	1207	2656	3099	1166	15189
Employees (000)	66	103	173	129	104	153
Fixed Assets/Employee £(000)	39	14	30	11	5	35

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Throughout the world the industry is usually in a monopoly supply position and in developed areas it generally has little choice in the customers it serves. The works built are longlasting and the pace of change of technology is slow compared with that in many other industries. Energy, material and manpower inputs into the operating process are low, therefore costs related to invested capital form a large proportion of the annual budget.

Where the industry is well established with stable terms of reference the proportion of total national resources devoted to investment in it varies within fairly narrow limits, see Fig 1 and the result is generally relatively smooth and gradual changes in charges for its services.

However these conditions are not immutable and recently in England and Wales this relatively stable situation has been upset by the combined effects of the withdrawal of rate support subsidies, inflation which has a dual effect on both the costs of new works and the expense of financing them, and major implemented and planned changes in accounting practice and charging policies.

All these factors together with changes in the numbers of consumers and their demands on the system, new legislative requirements and consensus environmental policies have to be taken into account in the planning process which continually rehearses, analyses and reinterprets the scene for water authority staff, authority members, and the interested consumer and pressure group.

THE WATER MANAGEMENT CYCLE

Fairly pure water is a basic necessity of human life and it is also relatively cheaply obtained in many parts of the world (13p per tonne delivered in the Midlands). As a result it is used in all developed communities to an extent well above any reasonably defined basic threshold of need, privately by individuals, and by industry and public authorities. Its use generally results in soiling or total temporary local loss and, as water is also vital to other forms of plant and animal life and is an amenity in its own right, its use on any large scale calls for extensive treatment of used water before it is returned to the natural system (at a cost in the Midlands of rather more than that for supply). In addition, we all know that the natural system does not flow at an unvarying rate and therefore it is usually necessary to spend considerable energies dealing with its floods and droughts; and it is also essential to look carefully at the points and conditions under which water can be sensibly taken out and returned to the system.

The cycle of use, return and regulation of water flows with which planning deals at a physical level can be represented as shown in Fig 2. This illustrates clearly the many ways in which the various factors interlock in a 'Water Management Cycle'. In many ways this cycle is more important to most water engineers and scientists than the hydrological cycle, with which many will be familiar. It is this cycle which man has created and which he must therefore continually overhaul, regulate and develop. The cycle clearly interlinks with the hydrological cycle in which man is usually only interested in and able to regulate a part.

BOUNDARIES

Since April 1974 the major units in the Water Industry in the UK have returned after a long absence to the fortunate position of being in control, under one Authority in one area, of almost the whole of the water management cycle. There are further considerable advantages in being able to operate not only an

integrated set of functions but also on an areal basis which does not give rise to the need for a major proportion of cross-boundary problems. Unfortunately from the point of view of deciding administrative areas for Authorities and Units within them, the two cycles with which we are most concerned often do not run within similar boundaries. The water management cycle is largely conditioned by demographic features whilst the hydrological cycle is conditioned almost entirely by natural geographical features. Often the presence of a steep range of hills will determine that the relevant features for both cycles can be contained within similar boundaries and this eases the problem; but this is not always the case as is clearly instanced in the centre of this country around the Birmingham/West Midlands conurbation which neatly straddles the catchments of the Severn and the Trent. Inevitably in these circumstances some form of compromise has to be reached and it is usually logical that the factors governing the major requirements for expenditure and effort are those most taken into account in determining the particular boundaries. Hence, for example, the Severn-Trent Water Authority's Tame Division, whilst centred principally on the catchment of the River Tame, has boundaries for several purposes containing parts of the catchment of the Severn and it follows demographic rather than catchment boundaries. Political and demographic boundaries are often superficially similar in nature but they are often very different in reality. It is therefore very important that we do not allow the boundaries of Water Authorities and their functional units to be over conditioned by political boundaries when these are based for the water industry on irrelevant historical considerations rather than relevant demographic or geographic features. We are fortunate in the UK that this is not at present a large problem but, elsewhere it can be where rivers form or cut through major political boundaries, as in the case of the Rhine for example.

DEMANDS FOR SERVICES AND FOR ACTION

Before discussing demand it is perhaps necessary to state the planning philosophy on which the views set out below are based. First it is best that all forecasts are made initially in terms of the actual throughput, or quantity most likely to be made available, at an average rate over a given period at a series of dates in the future. This short-circuits arguments about the difference between demand and need and the necessity for adding margins in forecasts to allow for delays in authorisations to start works, peak load or other special factors etc etc. It is not that these arguments or factors are unimportant but simply that, if they are built in at the outset, they tend to confuse thought and it is usually better if they are dealt with individually and added or subtracted specifically for particular purposes in a premeditated and identifiable way. The word 'demand' is taken to mean the forecast of the actual supply of service which the Authority is likely to make available, implicitly at similar standards to those obtaining at present unless specifically stated to be otherwise, and also implying that this supply will sufficiently match demand and be sufficiently above need to minimise the necessity of considering these factors in greater depth.

Secondly, in analysing demand it is almost always necessary to develop some suitable breakdown of accumulated totals so that one can separately identify the effect of the major factors likely to influence future trends. In looking at all the major water services for which UK water authorities are now usually responsible - supply, drainage, effluent treatment, flood alleviation, water amenity and recreational development - the following simple breakdown of total demand into 4 broad types has begun to be helpful:-

1. Demands arising from the need to maintain and renew the existing system at current standards of service and

throughput. Abbreviated to MAINTENANCE for simplicity.

2. Demands arising from any planned improvement in quality or reliability of services. Abbreviated to IMPROVED STANDARDS.

3. Demands arising from supply of existing services to new consumers in new locations and any subsequent growth allowed for in making that provision, together with the supply of totally new services. Abbreviated to NEW GROWTH.

4. Demands arising from growth of throughput to existing consumers in existing locations. Abbreviated to EXISTING GROWTH.

In planning to meet these demands one needs to classify the customers or beneficiaries who are going to be satisfied under the following three generalised headings - Domestic, Commercial (includes manufacturing, agricultural, service, and leisure industries), environmental (includes improvement in existing environmental standards). The use of this matrix of beneficiaries and types of demand or need is seen as being useful, not only to planning, but also in monitoring the Authority's achievements as capital is invested and year-by-year expenditure takes place. In particular it is seen as a means of setting targets for attainment which will eventually be used to bridge the gap which now exists between broad policies made by Government, Authority Members, and senior management on the one hand, and the people who construct, operate, charge and pay for individual works on the other hand. It is therefore seen for example as a way of bringing together the long-term development of charging policy with the analysis of investment and spending patterns, but it does not need to and probably should not attempt to supplant traditional analysis by type of water services provided because the two forms of analysis are complementary.

DEMANDS FOR 'MAINTENANCE AND RENEWAL'

At the present time there is no generally accepted method of forecasting the progression of demand for maintenance and renewal with time, nor even for measuring what is currently being achieved. Yet in a situation of only modest growth it is likely that this need will form an increasing part of the total call for action, first because the rest of the programme can be expected to decrease, and second because much renewal work which might otherwise have been done (sometimes prematurely as part of a growth and redevelopment package) may eventually have to be undertaken in its own right at greater unit costs. To get an approximate feel for the size of the problem one could assume that an average life-to-failure of water services items was say 100 years, and that with total replacement values for the whole system on modern lines for England and Wales of say £15,000m to £20,000m an investment on renewal at a rolling annual average rate of around £150m to £200m might be appropriate. There are, of course, many reasons for disputing such a figure. On the one hand the value of the system is unknown and indeed unknowable with any precision. On the other hand, the lives of different parts of the system vary enormously and can vary from being almost perpetual given reasonable care and maintenance, to 10 or 20 years given current rates of advance in say electrial and mechanical equipment. One might expect the actual as opposed to the potential investment rate to be much lower than figures calculated by this type of approach, simply because, as already noted, much renewal investment is undertaken concomitantly with growth or improvements in standards, and hence at considerably lower unit costs. Finally a look at past investment patterns for the industry, Fig 3, suggests that the greater proportion of works is of relatively modern origin

and therefore unlikely to need substantial expenditure on renewal in the medium-term future.

In view of the longevity of many water industry assets there is a need to push the graph of capital investment back well into the last century, towards the Victorian roots of the modern water industry, and research into this and methods of working from this data through the attentuating factors of time to a sound theoretical base for assessing the likely scale of demand for renewals in the future is currently being pursued. In the Severn-Trent Water Authority at the moment, a general policy of planned renewal has been adopted only for those mechanical, electrical and other features whose failure would lead to costs to the Authority and its consumers manifestly higher than the cost of replacement. For the rest of the system the policy is one of containing the rate of default within acceptable limits. On such evidence as is available of rates of failure or deterioration of service and consumer complaint, the indication is that present investment rates in UK are about adequate. From all points of view the position will bear considerably more applied research, both at the desk and on the ground. The first point of concentration of this effort will be on how fast we are really renewing the system at the present. For this analysis it will be necessary to classify renewal as the prime purposes of any investment including it and to treat other purposes as secondary.

DEMANDS FOR 'IMPROVEMENTS IN STANDARDS'

By far the larger part of the piped UK water services are generally held to operate at a satisfactory and publicly acceptable standard, bearing in mind the inevitably high costs and arguably low benefits of wholesale general improvement. Having said that, there are a very few, generally well recognised, local areas of substandard service. This situation is hardly surprising in a country where water services have a long and relatively stable history, but elsewhere the situation may be considerably different.

The shortfall from a generally accepted standard may be evidenced by either unreliability or poor quality of services. Usually it is the former which makes the major headlines in UK as it did in some local areas during the intense drought of last year. Poor quality on the other hand is generally a more persistent condition relating to say poor taste or permanent discolouration, and often these features become accepted or at least tolerated locally and are only criticised by newcomers to an area or when large scale development takes place. It appears possible that this question of ranges of acceptable through to desirable standards is one of the few issues which could benefit from greater national as opposed to local or regional analysis and determination in a fairly tight, socially and climatically homogeneous area such as the United Kingdom.

Environmental standards in the UK water industry have long been held to be unacceptably low ever since our forefathers started to pipe water into premises and then discharged it after use, virtually untreated initially, into man-made and natural surface water carriers. The results in areas of intense development or industry were often disastrous and although in the UK we have now made vast strides from this position, similar inprovement has not taken place everywhere else.

One of the major problems in consistently and logically assessing the demand for improvement in environmental standards is the lack of any established method of quantifying the factors to be taken into account in deciding on the relative merit of different schemes of improvement. Some

research into a pragmatic approach into this technical problem is long overdue. The general rate of investment in environmental improvement is always likely to be conditioned by what a triangle of consumer interests, government, and pressure groups, think the nation, the area, or the consumer can or should afford. This is likely to remain a political compromise and judgment. The result will depend as much on the relative political effectiveness and power of the contestants as on any process of explicit logical deduction; nevertheless it remains the planners duty to provide a logical framework and factual information on situations and consequences as guides and major input to this process of decision making.

Generally, therefore, it seems that capital investment and increased year-by-year spending on improvements in standards of the piped services in the UK is likely to be relatively small and that, as a position of diminishing returns is reached, the massive investments of the last 20 years (Fig. 3), much of it on environmental improvement, is likely to continue to be scaled down to a lower level. A satisfactory method of determining the level which is desirable or necessary has not yet been found.

DEMANDS FOR 'NEW GROWTH'

In the past, demands arising from new growth have been a major call on water industry investment and annual spending (in addition to that arising from growth of throughput) because of relatively rapid development, principally of new housing areas and indeed of whole new towns, and to a lesser extent of new industries and new industrial areas. By far the greater proportion of that investment has been in laying pipes and a lesser part in providing local storage and treatment capacity. During the mid-1960s, forward projections of population growth by demographers and economists reached something of an extreme high, see Fig. 4 'Recent population forecasts in the Severn-Trent area'. In these circumstances, the provision and availability of forward capacity of water services became a critical issue in determining whether development could actually take place and as evidenced in Fig. 3, rates of investment accelerated rapidly. More recently, population and industrial forecasts have tended to fall to what may prove a pessimistic low point, but the inevitable result of past actions, even if one takes a middle road around, say, a simple straight line projection of past trends, is that there has been a substantial increase in forward capacity availability in the system. What local authorities and others are now seeking to do, to the best of a rather limited ability, is to encourage development to take place where capacity is already provided. Hence, it should be possible to manage for a good number of years with a much lower rate of investment in the provision of forward capacity than has hitherto been necessary.

There is no accepted and reliable method of monitoring. How much forward capacity is available in the system except perhaps in one or two fringe areas such as water resources provision, is an enquiry to which one can often only give qualitative answers. Within Severn-Trent as part of the process of liaison with Planning Authorities we are steadily trying to develop an effective method of classifying and quantifying the situation. However, local authorities collectively may now be in the position in some areas of having already granted more planning permissions than are likely to be taken up in total by the turn of the century, and some of these fall outside the development areas designated in their draft or putative structure plans. In this situation the problem is intractable in the extreme, particularly as it is often the case that while one, two or even three of the Authority's major services may be adequately available, a fourth is lacking or misplaced. To a large extent this is a result of the inheritance of the single function

approaches of the past 50 years and the situation is slowly being improved as the Authority's multipurpose Divisions come to grips with their areas; but in a low growth situation the problem is much less readily resolved than in a time of high growth and relatively rapid provision of new capacity.

GROWTH FROM EXISTING CONSUMERS AND GROWTH OF THROUGHPUT

Growth of demand from existing consumers is one of the areas where demand forecasting by our predecessors was fairly well developed and rehearsed. Nevertheless there was some justifiable criticism of some of the forecasting and extrapolation techniques used. Severn-Trent inherited a large number of differently based forecasts from many of its 341 predecessors, and the planning view quickly developed that the totality of these forecasts needed urgent and thorough review. This was made particularly necessary because many of the forecasts had been made during the mid-1960's when, as already noted, expectations of population and industrial growth had been markedly higher than they were at the time of the Authority's formation. The view was relatively quickly reached that the existing throughput and its future growth could best be subdivided into four principal headings:- Metered industrial and commercial use; Domestic use (largely unmetered); Miscellaneous uses (largely unmetered); and Leakage (unmetered).

Assessing current metered consumption obviously presented little difficulty, although forecasting its growth was and still is problematical. Growth had correlated fairly strongly with GNP and other similar economic factors over most of the past 25 years, but there had been a recent trend of decline greater than could be explained by the short-term decline in industrial output; and in any case future forecasts of economic activity were many and varied. In the initial revision of forecasts made by the Authority in the autumn of 1975, the forecasting of industrial throughput remained one of the least satisfactory features and it is now the subject of intensive market research to determine the factors influencing particular components of demand. For this purpose industrial and commercial demand is initially being subdivided into nine types of use, ranging from evaporative cooling, through process water to personal use by employees. Different influences, from charges for treated effluents to numbers of employees per unit of output, clearly all have their own separate influences on these components. Analysis on this basis will permit much more sensitive forecasting using explicit assumptions for changes in each major influence on demand such as increases in productivity, changes from wet to dry processes, effects of trade effluent charges and changes in cooling practices.

It was found that some inherited forecasts had largely equated unmetered throughput with domestic demand. This approach was rejected as being untenable and the unmeasured component was divided into three major parts. The information available from metered domestic properties at Malvern and elsewhere indicated that average domestic consumption per head was probably in the region of 100-120 l/p/d and a regional average figure of 115 l/p/d was taken at that time. Although individual consumptions vary considerably from these figures the averages over quite small towns and certainly over larger areas could not be expected to vary from these figures by a great deal, chiefly because there are no socio economic factors in UK to indicate a basis for such variation. An approximate analysis was made of the way in which water was used domestically for various key purposes from toilet flushing, through bathing and clothes washing to garden sprinkling and usage by machines. On the basis of this breakdown a forward projection of domestic consumption, making explicit assumptions for each factor, was made. This showed that domestic consumption was not only the largest component of total throughput but was also likely to

prove the most rapidly growing, and it was therefore decided that some form of market research in this area would be first priority. Extensive consultation of the literature revealed that possibly due to its monopoly supply position throughout the world, the water industry has done surprisingly little to find out how and why its product is used by domestic consumers. To cut a long story short, the result was the selective metering of a carefully chosen sample of 1,000 properties in two very different towns - Malvern, which had grown mainly as an 18th Century Spa and a residential centre and Mansfield which had grown chiefly in the 19th and early 20th Century with the mining industry. In addition an establishment survey of the socio-economic and water use characteristics of 5,000 properties was carried out across the whole of the region in order that the results could be applied across the region, and possibly in other areas. These studies are now complete and are being separately reported elsewhere, Ref 2. They have confirmed that market research is an appropriate way of investigating the demand for water services and that the assumptions made in 1975 were reasonably correct although it now seems that **our estimate of average domestic consumption was slightly too high and should have been in the range 110 - 100 l/person/day.**

Miscellaneous unmeasured uses were analysed by categorising metering and other related policies area by area throughout the region. On the whole this is a small use averaging only about 5% of demand and not likely to increase much with time. This process therefore provided sufficiently accurate forecasting information. The inevitable conclusion was that the remaining throughput could only be accounted for by varying rates of leakage in different parts of the system and a method was developed of codifying the factors likely to influence leakage and quantifying their individual effects together with an assessment of what was likely to prove an acceptable economic level of leakage in the future.

The result of this analysis was that in 1975 Severn Trent reduced its assessment of the total increase in throughput to be made to meet the needs of new and existing consumers to the turn of the century, from its predecessors figures totalling just over 100% to about 40%. Experience over the last two years, including a continued reduction in unit industrial consumption in many areas, further reduced population forecasts, and different forecasts of economic and population growth, are now being used to prepare a biennial revision of our 1975 forecasts. This is likely to show only minor changes in the forecast increases in throughput. It is important to note that these percentages are from a low base compared with that used in several other parts of the country and places abroad. The inference is that leakage rates in many places are higher than previously declared, and, that they are being forecast to increase in absolute terms per head. The effect of these major revisions of forecast throughputs has been that it has been possible to scale down the design of or defer many projected works and this is now becoming quite apparent in the size and shape of the Authority's medium term capital programme, shown in Fig 5.

PROBLEMS OF PRIORITY

Having made an assessment of demands for action by the Authority, the problem of assessing the claims of competing priorities remains. Often at the end of all the analysis and argument a good deal of subjective judgment and indeed expediency must always come into this type of decision making. Nevertheless, the results are likely to be more consistent and satisfactory if this is carried out within an agreed and logical framework. No water service or need has of itself a priority over all others. Whilst it is sometimes held that this must be true when all other things are equal, experience suggests that all other things never are equal. In fact priority for any service is dictated by

the standard and quantity of service that it has been explicitly or implicitly agreed to provide at any given date and place, and the existing standard and quantity of service. The difference between the two has been termed a 'planning gap' by the Northumbrian Water Authority and it is the size and value of this planning gap which determines priority. Having said that, some quantities and standards are relatively hard and immutable in the medium-term in which solid decisions on action must be taken. For example, there is a relatively tight range of acceptable standards of supply of piped services and the quantities of throughput which are necessary once a piped service has been provided. These are fairly heavily predetermined, and largely beyond the Authority's direct control. Conventionally it is expected to supply all reasonable demands, which means most demands. On the other hand there is more flexibility in determing what improvements in environmental standards should be made and the rate at which these should take place and by changing these views the size of the planning gap for these demands is altered and indeed can be altered in relation to the likely finance, manpower and expertise available to bridge the gap. Similarly, an Authority has fair latitude in its standards of maintenance and renewal of its services in the short-term, although clearly its best interests are served by a regular rather than a lumpy, hit-and-miss programme. In large Authorities these maintenance issues are not brought up for consideration on an individual basis to decision makers with short-term expediency uppermost in their mind, and the tendency to unreasonable lumpiness in the renewals programme is generally avoided.

TRANSLATING DEMANDS INTO ACTION

First thoughts are almost invariably that an increase in demand must call for a corresponding increase in capacity. Second thoughts are often to consider whether the increased demand can be met through the existing system or whether the demand itself can be modified. Recently the relatively stable relationship between demands and consumers' incomes and costs has been upset as noted earlier by the withdrawal of support subsidies, inflation effects and other factors. This has given a new impetus to turn, once again, to the old question of the effect on demands of price, charging methods, public relations and direct controls. However before considering these factors more carefully it is necessary to give some more thought to the following equation.

Demand for new works = Direct or indirect use $\mp$ Change in leakage/infiltration rate $\mp$ Change in forward capacity provision $\mp$ Change in use rates - Existing capacity

Usually the water industry is first on site with its local services. The obtaining of planning permissions etc and design of trunk mains and sewers, treatment works and sources requires that the industry works to long lead times and these together with the economics of underground construction means that it builds into its systems a fairly high proportion of forward capacity in relation to the growth of demand. This capacity inevitably acts as a buffer between changing forecasts constraints on the capital programme size and the immediate on the ground ability to provide supply, disposal or drainage facilities.

The result of this buffering is important in that the short term effect over a couple of years of significantly lowering demand forecasts is not to reduce the size of the investment programme, but to increase the forward capacity margin. Conversely the immediate effect of reducing the investment programme made up of a multiplicity of schemes by quite large amounts in the order of say 20%, is to reduce the forward capacity margin rather than to stop

supplies being made. The problem of logically and numerically analysing the demand for action equation is a complex one, often only partially understood, with the result that inept questions about the industry and an authority's programme are often asked, and as a result misleading and professionally unsatisfactory or vague answers have to be given.

Recent events in UK including changing standards, particularly for discharges; reductions in supply and disposal forecasts; the realisation that a good deal of local authority planning has been writing down what was seen as desirable rather than what was most likely to happen; have meant that forward capacity in relation to growth has undoubtedly changed, but aggregate numbers are hard to come by. Measurement is however essential if the industry is to be able to make a sound case to justify its ability to live with about half the investment rate of four years ago and the possible need for some greater rate of investment in the future.

ECONOMIC INFLUENCES

We have already seen that only a small part of the total demand for investment and spending by an Authority can be directly sensitive to changes in the charge for the quality of service provided. The result is that savings made by measured consumers generally will, in the medium and even longer term, result in higher unit charges to them. This is not a very happy situation although the individual consumer making above average savings will still be at a clear advantage if he is reliably charged by volume. In the UK, however, well over half of the industry's income is received through standing charges on property very roughly related to that property's water using potential rather than its actual use. On the whole, this has proved an economic, efficient, and tolerably equitable way of collecting revenue from domestic consumers bearing in mind the very high proportion of the industry's costs which are not sensitive to short or medium term variations in throughput.

In the medium term the factors influencing the average size of the consumers bill are likely to be dominated by the planning of monetary rather than physical matters, as Fig 6 clearly illustrates. Here it will be seen that present and future possible changes in methods of paying for use and renewal of the system through depreciation under existing rules and projected methods of current cost accounting become, after inflation, the biggest single influence on revenue requirements. Following that, short term instructions by government on the way in which budgeting is to be undertaken can lead to quite marked fluctuations in the rate of progression of charges in relation to inflation, see Fig 7. The result tends to be that economic indicators which might lead to changes in demand patterns become too confusing for the average measured consumer to follow and make a rational response. Nevertheless one would expect to see a long term accumulated response to long term trends in charges as consumers generally gear themselves progressively to a changed level of water charges, making changes to their operating plant and practices when this conveniently fits with other demands on them for change, e.g. the introduction of new processes or the extension of a plant.

This slow and low key response to economic pressures - low elasticity of demand in the economist's vernacular - also seems to be reflected amongst domestic consumers. The evidence from consumption records in Malvern where domestic supply is paid for through a meter is that households in similar socio economic and physical circumstances use very similar quantities to Mansfield households where domestic supplies are unmetered. Also unpublished analyses of consumption in Malvern show very little change in unit rates of consumption even when unit price rises of the order of +50% in real terms have been brought about by charge equalisation policies and other measures.

For industrial consumers, particularly, there is nevertheless a possibility that the cost of water authority piped provision of service may reach a point where it is cheaper for some of them to begin to make their own provision. This possibility will be magnified and to some extent distorted where, as part of a price averaging policy, water authority unit costs begin to be well above the minimum local cost. This phenomenon is likely to be particularly marked in the field of treatment and disposal of trade effluents where costs of different processes can vary widely; but it can also be important in the provision of water supply where local resources, particularly of not too hard groundwater are available.

PHYSICAL CONSTRAINTS/LEGISLATION AND PROPAGANDA AS INFLUENCES

These influences can be brought directly to bear on a widerarea of the demands for action than can pure economic forces. Starting at the highest level, government can usually through legislation and powers of direction limit either the rate of investment of the industry or its charges. In so doing it can suggest or even require that certain of the softer demands generated by upgrading standards are reduced. More usually governments seem to act as stimulators of demand through underwriting in legislation calls for higher standards, particularly in the environmental field, and also in relation to quality of service. Often this appears to be particularly true where the legislative processes are more than usually complex in both administration and motivation, as in the European Economic Community; as a result the relationship between these controls and demands and what consumers and beneficiaries would themselves have given strong evidence of wanting, appears tenuous.

At a humbler and more direct level a great deal to influence domestic demand can be done by simple physical measures such as requiring the use of 'water economy' equipment. Often the general use of these measures, such as dual flush systems and minimum water use domestic appliances, requires legislative back up, including powers to make and enforce byelaws and selective use of propaganda. But the effects are real and often long lasting, and must be carefully taken into account in forecasting and planning. Demand for throughput arising within the system can be controlled without the need for legislation, through reducing leakage by limiting high pressure zones for example, but some form of legal control is required in addition to economic incentives in working with many measured consumers. Nowhere is this more true or more effective than in the field of effluent discharge control. Where increasing physical - legal controls are worked in the same direction as increased economic pressure through higher or more selective charges the effect can be relatively dramatic, as has been seen in this country in recently declining rates of industrial water use and discharge much greater than can be accounted for by a slackening of industrial output.

Propaganda effects on demand tend naturally to be short-lived; but where "wolf" is effectively cried, when wolves are rare but now clearly to be seen, the effect can be very significant and timely. This was nicely illustrated by events during a manifestly extreme drought in the UK last summer. The efficacy of this public relations exercise has now been demonstrated and measured and it can now be one of the factors taken into account in planning for extreme circumstances. On the other hand, the consumer clearly does not pay his water charges to hear "wolf" cried too many times in a lifetime.

CONCLUSION

My purpose in writing this paper has been to set out the thinking behind the

size, shape and type of planning framework which is now being created. Its purpose is to provide a rational and consistent basis for action and for explanation of actions to Authority Members, Government and increasingly well informed pressure groups. In the Midlands these include not only the fishermen, environmentalists, local authorities and landowners but also consumer organisations such as the Confederation of British Industry, the National Farmers' Union and more recently the Birmingham Consumer Group. I have deliberately not dwelt on the particular programmes and items of work which are sanctioned by the planning process after all the considerations of why, for whom, and when they should be built. These should follow from an understanding and acceptance of the planning framework which an authority has implicitly or explicitly developed. Engineers and scientists will then have to adopt each works proposal to the particular circumstances of its location and they will wish to describe one at a time new problems and new techniques as these are called into play.

Planning cannot and should not try to foresee in some crystal ball a blueprint for the long term future. It certainly should not seek to ensure that such a blueprint is implacably followed. Rather it is concerned like the manager of a football team to rehearse the objectives, strengths, weaknesses in a situation and the alternative courses of action which can be taken when different pressures build up. Planning analysis will enable management and staffs, if they can be involved in the thinking, to react individually and collectively in a complementary and consistent way as the future unfolds. Such planning should minimize the need for sudden heart-rending changes of policy.

Having said this the football analogy cannot be stretched too far. Fortunately perhaps we live in a much less immediate world than that of sport and it is clear that in a monopoly supply position of a basic commodity at relatively low cost the medium term future of the industry is heavily determined by where we are now and where we have recently been. This means that in the medium term at least the size and shape of works programmes is fairly determinate and often neglected monitoring of current achievement of targets assumes an important role. Realistic and flexible planning allowing itself to look at all reasonable views of the future but refusing to be committed to works in the ground much further ahead than is strictly necessary will give staff in the water industry who have immediate problems to solve a better technical environment in which to work. Where changes in the focus of their efforts in collecting charges, designing and building works, manning and operating them and paying for goods delivered are required, these can then be brought about smoothly rather than in jerks and the staff concerned will have the opportunity to optimize their efficiency and job satisfaction.

REFERENCES

1. 'A Study of UK Nationalized Industries' National Economic Development Office, July 1976.

2. 'Mansfield and Malvern Studies of Domestic Water Usage' Proceedings of the Institution of Civil Engineers, Part 1 February 1978, (for oral discussion on 7th February 1978).

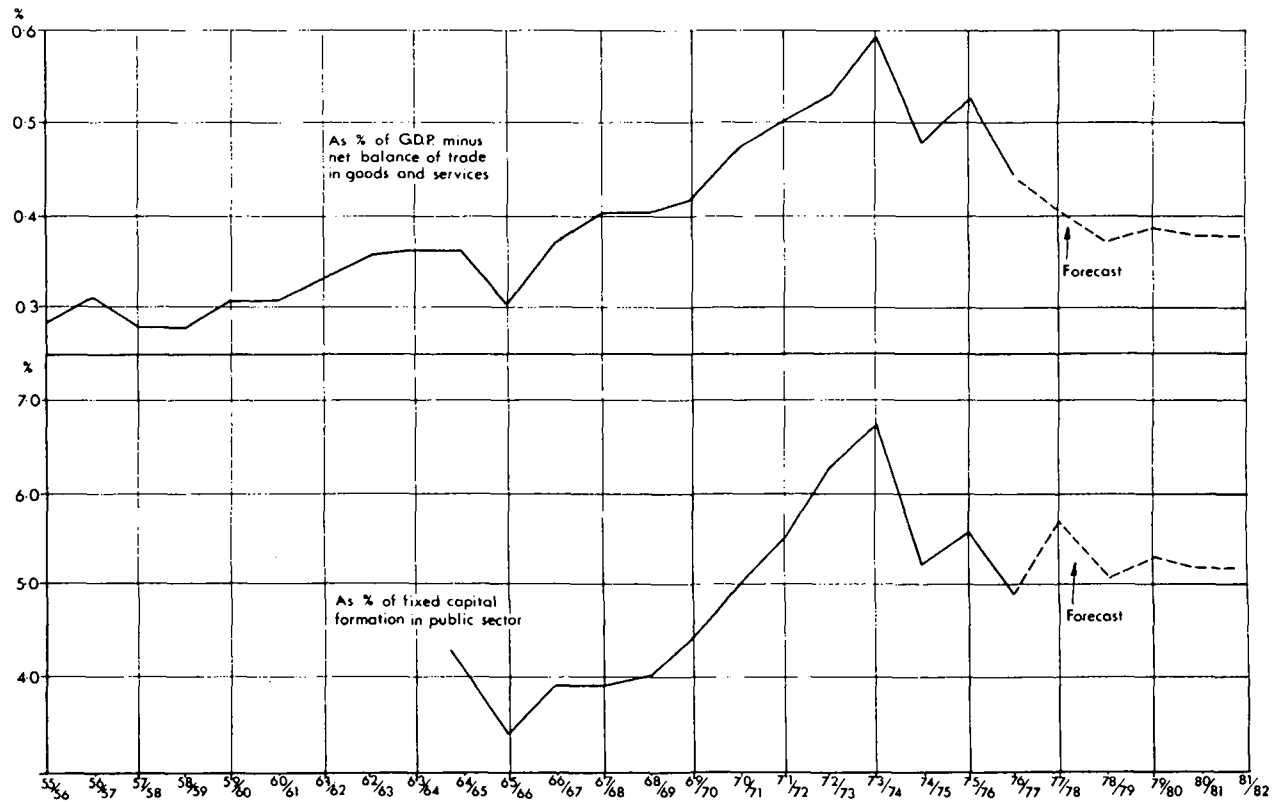

Figure 1. Capital Investment in National Water Services as a % of National Resources and Public Investment

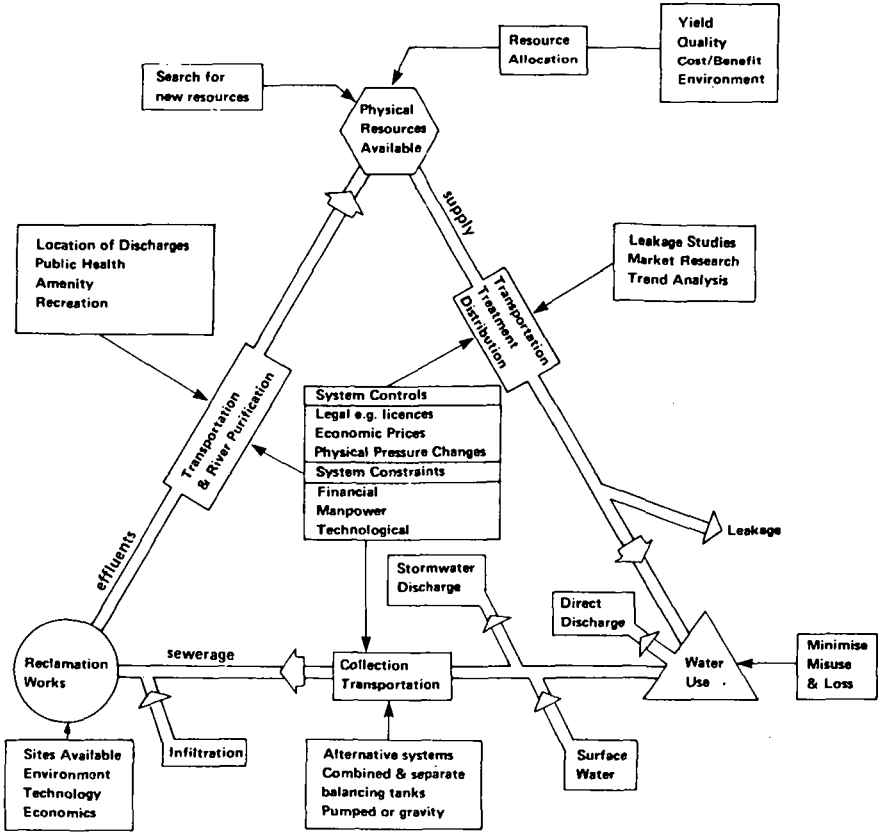

Figure 2. The Water Management Cycle

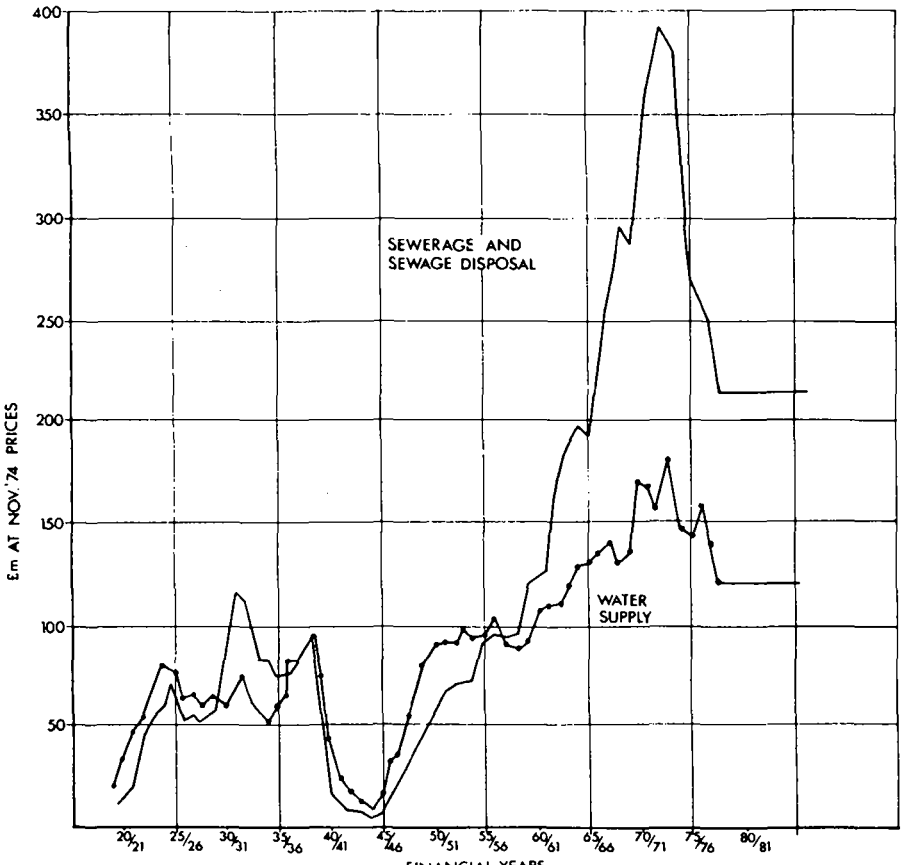

Figure 3. Investment patterns in the water industry 1919-1983

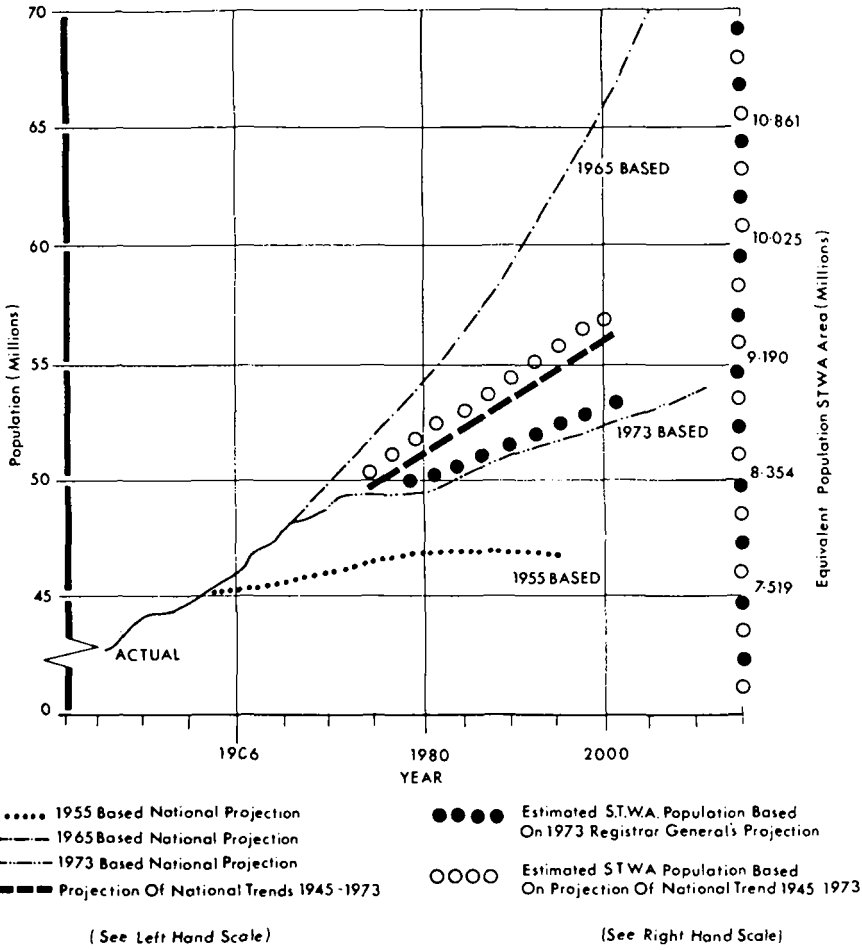

Figure 4. Recent demands and population forecasts in the Severn-Trent Region

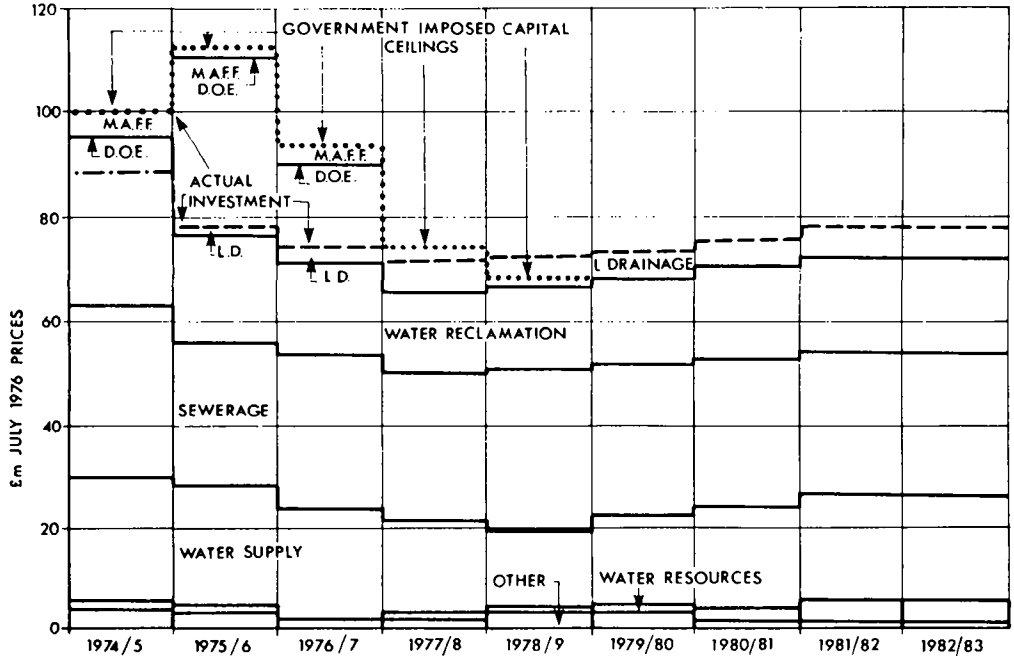

Figure 5. Severn-Trent Capital Investment Programme 1974-1983

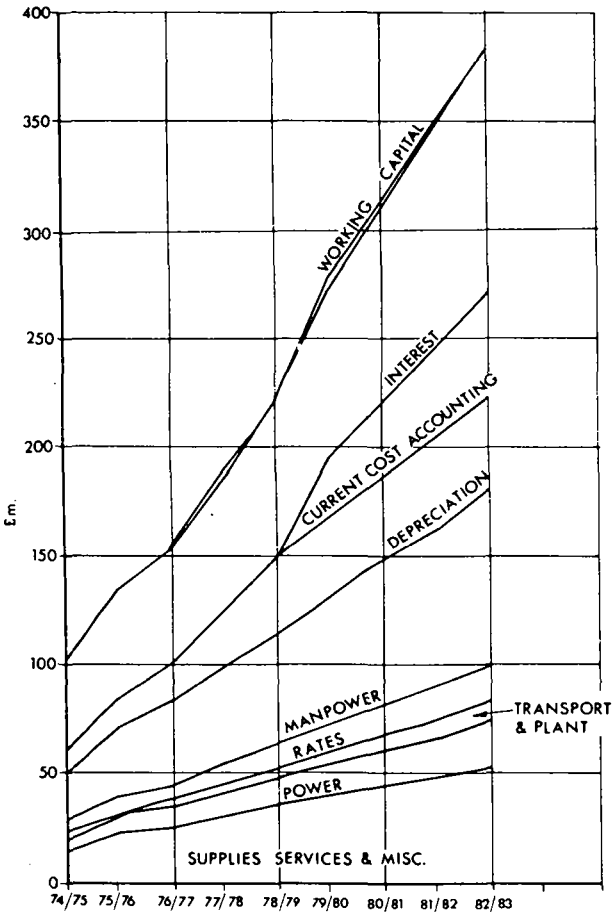

Figure 6. Severn-Trent Revenue Requirements 1974-1983

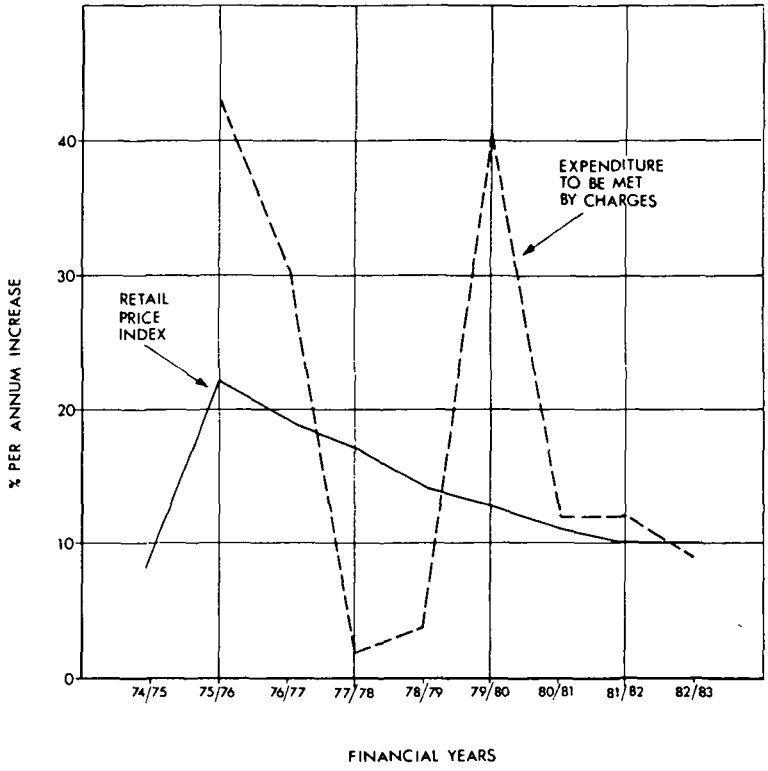

Figure 7. Progression of Charges and Cost of Living 1974-1983

DISCUSSION

Author's Introduction

MR. J.E. THACKRAY, in introducing his paper, noted that many would say that it was natural and right to put the subject of planning at the beginning of the symposium. However, experience did not lead him to expect such a view to be taken in practice in many cases. He therefore led into the subject by discussing the nature and reasons for planning, and showed that planning was a cyclical and interactive process, so that in practice, one could, and often did, break into the cycle at different points. Having said this, it was important to recognize clearly the point in the cycle at which one had actually broken in. This could well be illustrated by taking the analogy of driving to make a journey. Assuming that the journey was necessary, planning would be concerned with anticipating the problems which would arise during the journey on a minute-by-minute basis so that the driver could avoid lurching from one emergency to the next. All this would be fairly immediate planning, or what the author preferred to call "operational" planning.

At the other end of the spectrum, a level of conceptual and strategic planning should at some stage have been undertaken which might, and possibly should have, examined fundamental issues. Pursuing the driving analogy a little further, questions such as "Is driving the best way of making the journey?" or "Should we travel by train, bus, underground, or plane?" would have been asked. Clearly, there was no invariably correct answer to these questions. The best answer depended on the circumstances and might often be derived from a balance of conflicting forces. At an even more fundamental level, the question probably might have been asked, and often should have been asked, "Is the journey really necessary, or would a telephone call or letter do?"; or at an even deeper level, "Did we really need to pursue the objective which called for the journey to be made?".

All these factors affected planning and the question of timing of a particular planning input in this cycle of events was of critical importance. For example, it might have turned out to be singularly unwise to ask whether the journey was necessary at all, just as the driver concerned was stuck in an enormous traffic jam outside London; but nevertheless, it would be exceedingly relevant to ask that question next time a journey into London was contemplated. Usually, if a planner bided his time, the opportunity would come round for him to make his input, even though it might not always be welcomed the first time an issue was considered. In practice, the water industry was not concerned with a single journey but a series of overlapping and complementary tasks which were rolling forward through a cycle of strategic and conceptual planning, detailed consideration, implementation, monitoring, and feed-back. These tasks rolled on into the forseeable future.

Fig. 2 in the paper showed the outline of the water management cycle which man had created and had to maintain for his own convenience. It was complementary to and distinctly different from the hydrological cycle of nature which man also sought to regulate. In England and Wales, the water industry was fortunate in having almost all of the water management cycle within its control under vertically integrated public authorities. Fortunately also, political boundaries had been given minimum influence over the drawing up of water authority regional boundaries, and in most cases it had proved possible to encompass the boundaries, which influenced the water management cycle for a particular area, within the hydrological boundaries on which the water authorities were based.

The industry was capital intensive (Table I) and had a high proportion of fixed costs. It was also long-lived and relatively stable and took a proportion of the nation's gross domestic product which moved within relatively small bounds, as shown in Fig. 1. Nevertheless, it was prone to changes in fundamental approach by the Government and its consumers, as evidenced by the marked peak in the percentage of GDP consumed and fixed capital formation in the public sector shown in 1973-74 in Fig. 1, and by a corresponding peak in the investment graph (Fig. 3).

In order to forecast growth and change within the industry, and within the Severn-Trent Water Authority in particular, demands for action and investment and the beneficiaries of those actions had been classified as shown in Table II:

TABLE II Analysis of Capital Investment by Purpose and Beneficiary

	Household %	Commercial %	Environmental %	Total %
Maintenance	20	20	-	40
Improvement	5	5	10	20
Growth	10	10	-	20
Extension	15	5	-	20
Total	50	40	10	100

The percentage figures in Table II were deliberately rounded-off because the available analytical data was not sufficiently refined to enable the figures to be more reliably quantified. However, the improvement of this analysis was currently a high priority amongst planning and other staff in the Severn-Trent Water Authority.

Fig. 3 threw some interesting light on possible rates of renewal of assets. Taking the average capital investment of the industry as a basis for renewals was far too crude. It was hoped that most of the bulge in investment in the late 1960s and early 1970s would not need substantial investment on repair or renewals until well into the next century. In investigating current rates of effective renewal, the author had become aware of serious underestimating based on misunderstandings of the methods of analysis. In order to get the figures in his matrix of purposes and beneficiaries of capital investment, he had subdivided capital programmes *pro rata* into their various purposes so as to obtain consistency between the various figures. However, he held the view that it might be generally desirable to treat renewal as the prime purpose of any multi-purpose investment in order to obtain a reasonable value for the extent of a system which was to be replaced in any mixed-purpose scheme. Of course, every purpose could be taken in turn as the prime purpose for a mixed-purpose scheme: then the total cost would be subdivided in proportion to these figures to arrive at *pro rata* shares for global analysis of total investment programmes. The evidence so far available on the renewals issue tended to suggest that much higher rates of renewal might be called for in some regions than in others. For example, statistics on projected housing trends over the ten years 1981-91 which were included in the Government's Green Paper on Housing, showed that in the North West Water Authority's area, it was proposed to build eight new dwellings for every new household formed; in the Severn-Trent area the equivalent figures were 2 to 1; and in the Southern Water

Authority area, equivalent figures were 0.9 to 1. Obviously several factors bearing on these differences were delved into more fully in the Green Paper, but the one which immediately came to mind in the context of water services was the variation in the rate at which old houses were being replaced with new houses, and the consequential implied variation which might take place in the need for renewing the attendant water service infrastructure.

In dealing with improvements in standards, the author noted that significant improvements in piped services appeared to be necessary only in one or two local pockets, although the Authority had not yet fully considered the issue of whether it should eventually aim to give similar standards of service over all parts of its area irrespective of costs. Conversely, the Authority was at present investing relatively heavily in improvements in environmental standards and as a result, the biological load being discharged to rivers through the Authority's works was being reduced at about 4 per cent per annum, which was a high figure compared with the 1½ per cent per annum increase in throughput being catered for.

Fig. 8 illustrated the way in which population forecasts had varied over the last few years. It seemed that forecasts might now have reached some new low point and be due for a round of increases. However, changes in population were not the most significant factors which had been taken into account in revising Severn-Trent's throughput forecasts, others being growth in consumption per head and leakage rates. One of the primary benefits of studying domestic consumption more rigorously had been to focus attention on the balance of unmeasured throughput, of which a large proportion was leakage. The studies conducted at Mansfield and Malvern into domestic water consumption and presently being piloted through on industrial water use would lead to a much firmer basis of forecasting in the future. For the time being there had been an interim revision of the 1975 forecasts. This showed that the 40 per cent increase in total throughput forecast in 1975 had not been affected much by the drought summers of 1975 and 1976; but the position would be thoroughly reviewed during 1978 and 1979.

Of more immediate concern to the Authority was the extent and variation of advance capacity which planning studies had revealed throughout the Severn-Trent region. This was not too surprising if it was remembered that the primary purpose of much water authority investment was to create advance capacity so as to provide the infrastructure for developing housing, industry, etc. Given the previous fragmented structure of the industry, it was hardly surprising that these variations existed, and a good deal of effort was now being devoted to rationalizing advance provision throughout the area and to encouraging developers to use existing capacity rather than to call for further increments of capacity to be added in new areas. He saw this rationalization as one of the benefits arising from the full integration of water services when they were removed from the direct but fragmented control of a variety of local authorities and *ad hoc* Boards. Looking at this picture, it had to be appreciated that the first effect of any change in forecasts of demands on the system was not to see immediately a change in the capital investment programme so much as to see a change in the Authority's perception of its advance capacity provision. This was why it was necessary to devote a good deal more attention to reliably quantifying what that advance provision was and what it would become in the future. Figs. 9 and 10 demonstrated, for one division, the basis of the approach being taken in Severn-Trent across all of its eight divisions.

In referring to problems of priority, he underlined the concept being

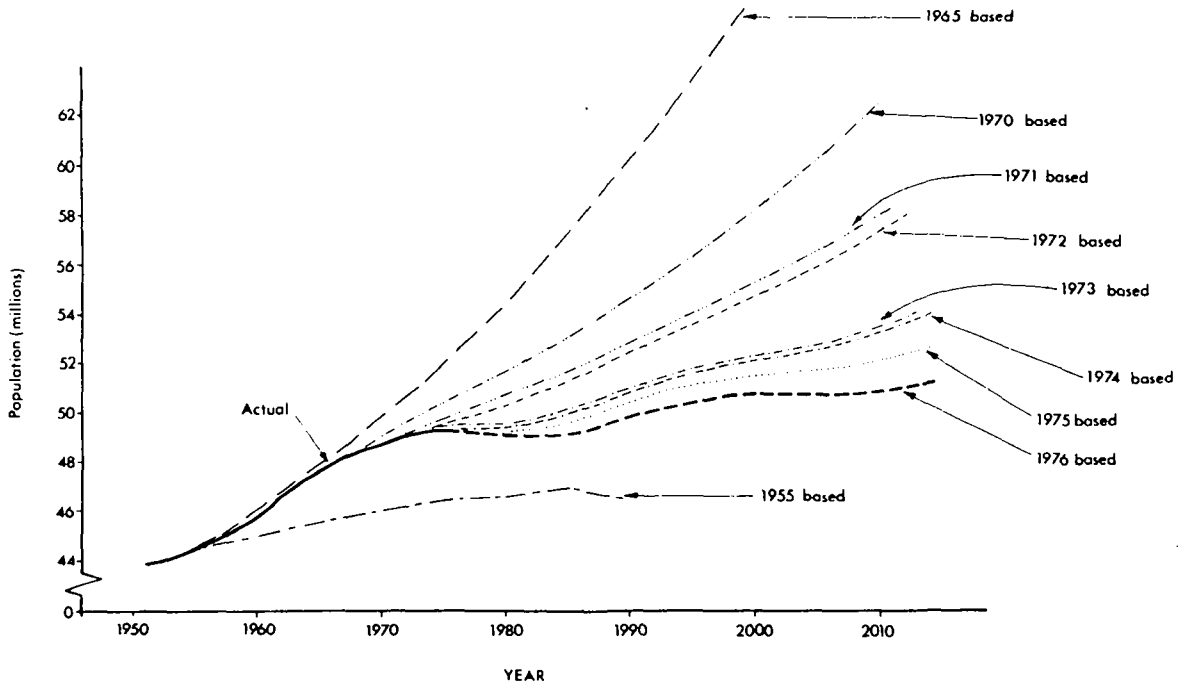

Fig. 8 Actual and projected populations of England and Wales

developed by many planners that no one purpose or service had intrinsic priority over the others, but that priority between services, or within a service, was more readily determined by reference to the "planning gap". This gap was the difference between the present standard and size of provision made for a service to meet a purpose, and the standard and size of provision deemed necessary. Thus there could be a very low priority even for a purpose like protecting public health if public health had already been protected to necessary standards.

Reference to the size and shape of the Severn-Trent Authority's five year projection of capital investment showed that approximately 30 per cent each was intended for water supply, sewerage, and sewage disposal services, leaving comparatively small percentages of about 5 per cent each for water resources and land drainage. This was important because it demonstrated that perhaps a disproportionate amount of public and ministerial attention had been devoted to relatively small, though important, components of the total water service. It continued to be important in planning to be concerned with things roughly in scale with their proportionate effects on the investment and revenue programmes as a whole.

More than one-half of the Authority's income came from standing charges related to property value scales (rateable values) used as a proxy for consumptive capacity. This was important because the water industry at present derived a greater proportion of its income from charges or levies related to rateable value than did local authorities, although of course their income was larger in absolute terms. Perhaps the recovery of this proportion of costs in standing charges might be considered not too far wrong on balance if it was appreciated that more than one-half of the Authority's costs were fixed or standing costs. However, to levy such a high proportion of fixed costs without having a seasonal differential of charges would lead to relatively low charges for each measure of water that was supplied and disposed of. The Authority's studies at Mansfield and Malvern[2], had already demonstrated that the elasticity of demand for water services was very low. There was some evidence in the industrial sector that the elasticity of demand might be higher, although it seemed that industry was generally reacting more to the constraints imposed on trade effluent consents and to a general slow-down in ecomomic activity than to the direct pressure of charges; the only exception to this possibly being in relation to trade effluent charges which were being drastically increased in some areas as part of a process of regionalization of charges of this type.

In general, it was found that certainly in the short term, physical constraints on demand produced greater effects than economic pressures, although in the long term, economic pressures might change attitudes. The Authority's forecasting was taking account of the changes which would come about in water usage when building regulations required the installation of dual flush w.c. systems in all new or altered property. Also, the changes in throughput which were consequent upon changes in water pressure were being taken into account.

Legal constraints had already been referred to in the paper and these had proved particularly effective, for good or ill, in curbing industrial water use and through controlling the quality of trade effluents discharged. The scope for control of demands through propaganda had been effectively demonstrated during the 1975 and 1976 droughts. This indicated that when the emergency was seen to be a reality, the public would respond and would probably prefer to respond in this sort of fashion once in a while and in

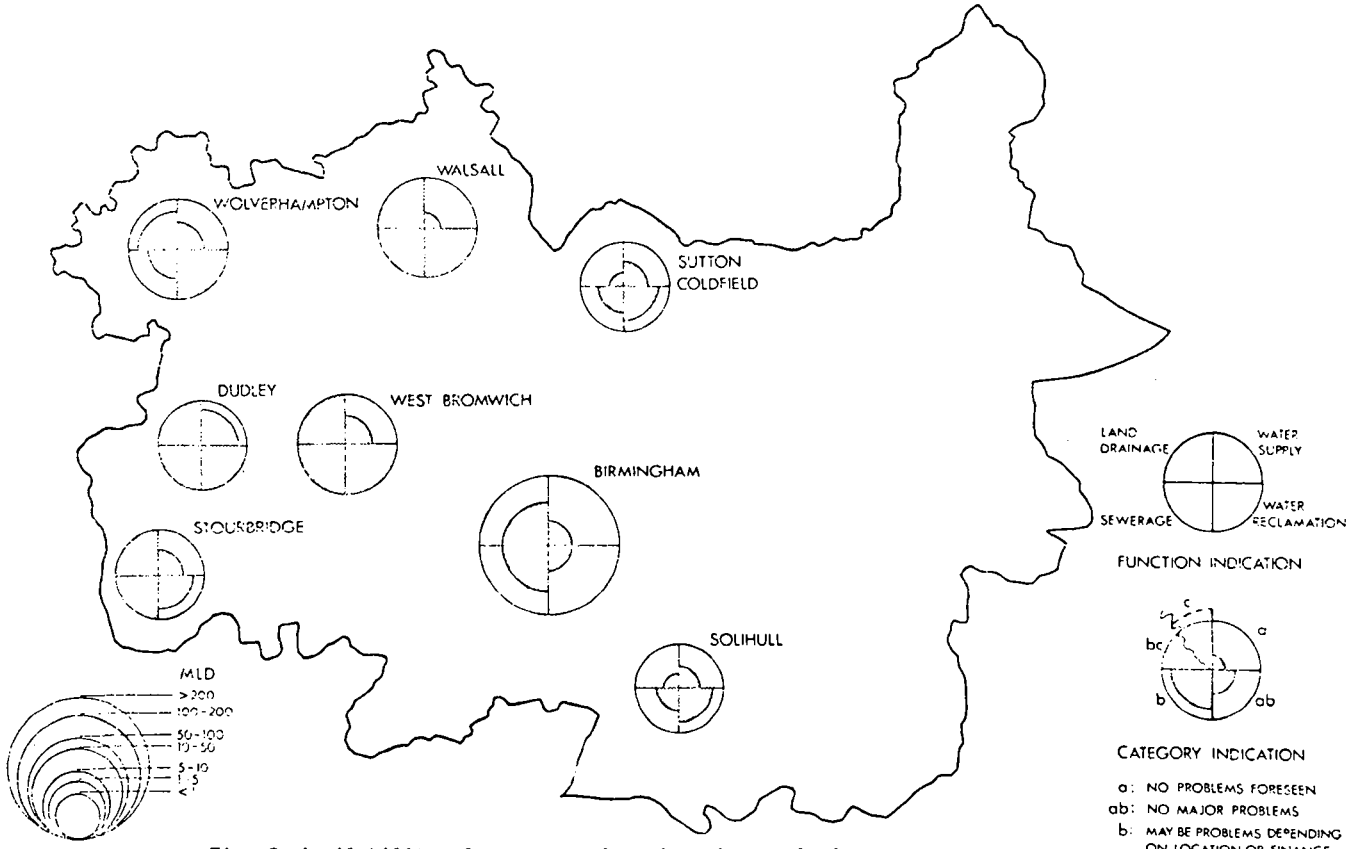

Fig. 9. Availability of water services in main population centres, Severn-Trent Water Authority, Tame Division, 1977-78

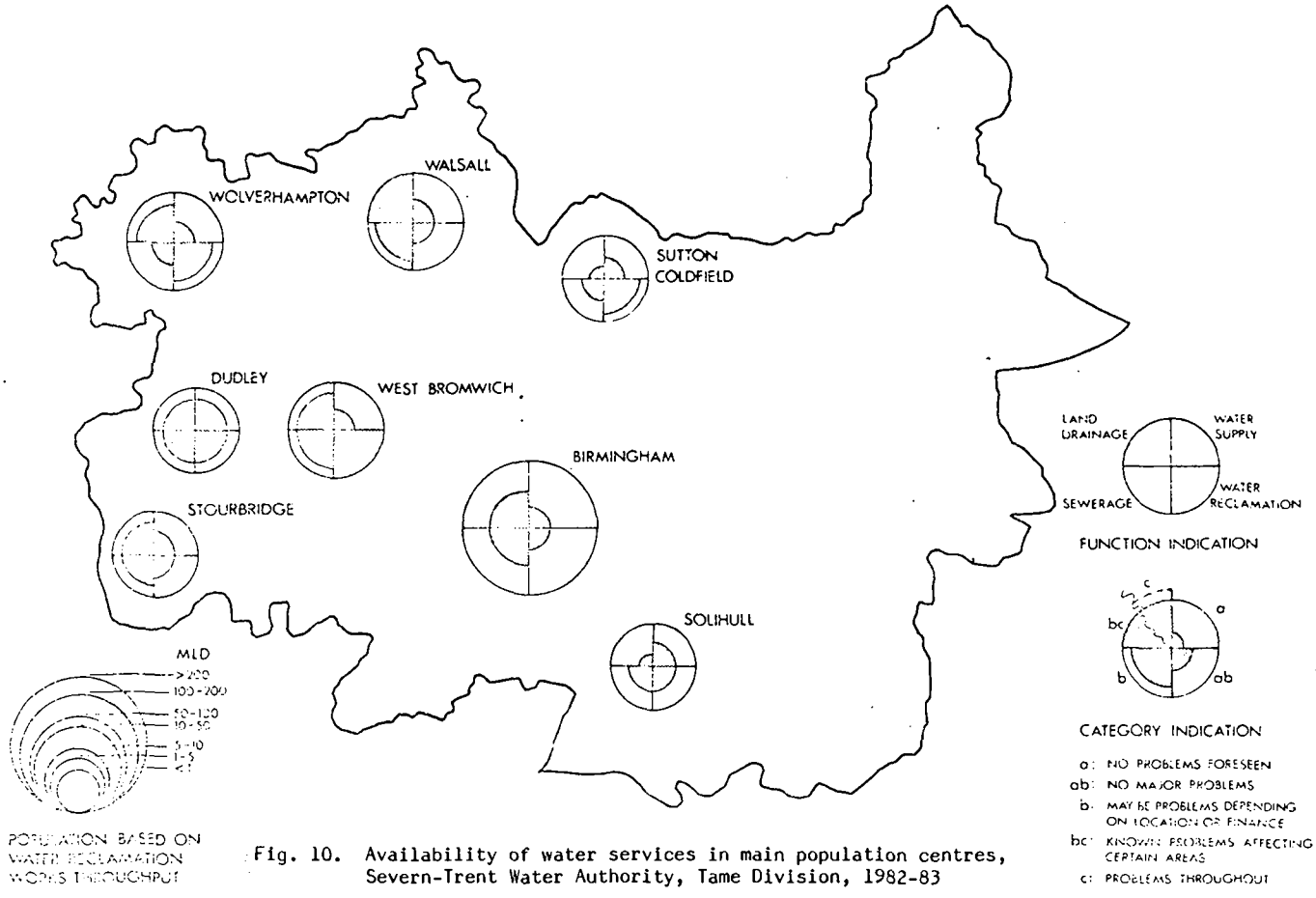

Fig. 10. Availability of water services in main population centres, Severn-Trent Water Authority, Tame Division, 1982-83

extreme circumstances rather than having their charges increased to buy a greater security of supply.

Concluding his presentation of the paper, he stressed that the success of planning would require attitudes to be realistic but flexible so that premature commitments, either political or practical, or legal or financial, were minimized and changes could be made smoothly rather than in jerks. In ensuring that this process rolled forward satisfactorily, it was essential to consult pragmatically with consumer and pressure group interests, who might range from national organizations such as the CBI and the NFU, the National Federation of Building Trade Employers, the National Anglers Council or the Countryside Commission, to local groups such as the Birmingham Consumers' Council, local authorities, and particular fishery, conservation or other pressure groups.

Verbal Discussion

MR. K.J.H. SAXTON (Welsh National Water Development Authority), in opening the discussion, said that the author's "water management cycle" (p. 1 2 and Fig. 2) was a realistic and, indeed, operational approach to the work of planners. The approach suggested by the author for analysing demand was one discussed at some length by the National Water Council's Directors of Resource Planning Group and found favour with the majority of that Group. In the allocation of expenditure to meet the various needs identified by the matrix-type approach, water authorities would play on the category of purpose defined by the DoE as work to meet public health requirements, but he left others to elaborate on this.

Having alluded to the Government's Notes of Guidance on Water Authorities' Annual Plans and Programmes, he thought that the author might have made brief reference to the change in thinking away from separate, medium, and long term plans, towards the more realistic concept of a continuous and iterative process, with the early years of the Plan dictated by on-going works, and with the middle years more precisely defined than the later years. In the later years it was information on the possible options which was important and not a hard and fast plan.

One of the greatest problems in planning was the determination of the standard of service water authorities should provide. Although the specification of an acceptable quality for drinking water might be relatively straight forward, the determination of an acceptable reliability of supply was not; and problems increased when attempts were made to specify discharge consents and what the quality of various rivers should be. It should always be remembered that the public must be willing to pay for the achievement of the standards set. Until standards had been determined, it was difficult to decide on priorities within and between services, and it was significant that in this paper, it was the section entitled 'Problems of Priority' (p.1 8) which was the shortest. It was here he thought that there was still the most to learn, and Mr. P.R. Herrington had some useful comment on this aspect in his paper. The gap between the academics and the industry was still wide and industry should be clarifying its thoughts more on where it wanted help from the academics in the resolution of these difficult problems.

He endorsed what the author had said in the section entitled 'Translating demands into action' (p. 1 9), in that a good deal of local authority thinking in their structure plans was inevitably along the lines of what was desirable, rather than what was most likely to happen.

Concerning Fig. 3 of the paper, he wondered if any of the delegates were clever enough to illustrate to what extent the ups and downs of the investment in the industry were due to forward planning, and which of them had been due to political expedience. He suspected the latter had in fact had a substantial effect. As to the future he considered that investments would continue to fall during the next few years and not stabilize at the present level as shown in Fig. 3. Others might think him wrong, but it was essential that planners knew what course of action to recommend in the event of either occurring and that when decisions had been taken, progress was monitored.

MR. L.E. TAYLOR (Central Water Planning Unit) suggested that Table I (p.l 1) illustrated the need for careful interpretation of information because it did not appear to compare like with like. The water industry had no sales force and, therefore, differed markedly from the other industries. If the sizes of their sales forces were known, in particular for the gas and electricity industries, new figures for fixed assets per employee could be calculated and it would then be interesting to see how the adjusted figures compared with those for the water industry. He wondered whether the author would like to comment on that aspect.

He thought that the water management cycle (Fig. 2, p. l 14) could be misleading, as it did not show the discharge of effluents to the sea.

Some figures had been given (p.l 4) for possible annual investment requirements on renewals, the size of which suggested that major studies would be justified in each water authority area. Normal practice was to renew when maintenance became uneconomical and the industry needed to separate expenditure on maintenance from that on renewals. He asked whether any authority had succeeded in doing so.

He drew attention to the final paragraph on p. l 6, which stated that there was no accepted and reliable method of monitoring forward capacity in a water services system. He thought that the problem was being considered in most water authorities and he asked whether anyone had considered investigating peak day demands in various parts of the water supply and sewerage systems. This could be done for water supply by monitoring the loss in mains, and for the sewerage system by monitoring the frequency of storm overflows.

He noted that growth of metered consumption (p.l 7) had correlated fairly strongly with GNP and other similar economic factors over most of the past 25 years. Analyses carried out within the Central Water Planning Unit on a national basis had not shown good correlation.

He doubted whether it was true to suggest that the metered consumer made a slow and low-key response to economic pressures (p.l 10). There had been a significant reduction in the supply of water through meters since 1970 and national figures showed that metered consumption had now fallen to the level of 1968. The reduction could not be attributed entirely to the sluggish national economy. It was more likely to be due to a combination of higher charges for water and higher costs of treating trade effluents arising from the more stringent control of discharges.

He was glad to have had the author's explanation of Figs. 6 and 7 (p.l 18 & l 19) as he had found them difficult to follow. It was alarming that the relatively modest increase in the forecast total demand for the

Authority's services should necessitate nearly a fourfold increase in revenue requirements over an 8-year period. Fig. 7 could be used to argue the case for charges to be based on a 5-year rolling average to smooth out the fluctuations.

Finally, in connection with the reference to propaganda effects on demands (p. 1 11), he drew attention to the British Gas Corporation's annual gas energy management award which was made to the industrial user who had made the largest increase in gas-burning efficiency during the year. He asked whether there was a case for a similar award in the water industry to the industrial user who achieved the greatest economy in the use of water.

In a written communication, Mr. Taylor took issue with the author's claim (p.1 5) that only a few issues could benefit from greater national analysis, as opposed to local or regional analysis. The following topics should be investigated nationally:

> Demand estimation and management; reliablility of supplies; recreation and amenity, i.e. the extent to which the different recreation and amenity uses of water were mutually compatible and consistent with other statutory functions; priorities for environmental improvements; quality criteria for water supply; groundwater quality problems; quality of estuarial and coastal waters; disposal of sewage sludge; trade effluent control; and urban drainage systems, i.e. the relative merits of combined, separate, and partially separate systems.

He appreciated that his view would not be universally accepted, but he hoped that the industry could agree to make the best use of available expertise in studying and solving these problems. There was a need for more co-ordination of effort.

On the more general aspects of the paper, the simplest definition of corporate planning was a systematic appraoch to strategic decision making. Its practice was well established in this country, and in the public sector such bodies as the British Gas Corporation, the Post Office, and the British Steel Corporation were using the approach while the Treasury and other government departments had their own versions of long range planning. The reorganization of the water industry was heralded as a corporate venture and the second report on economic and financial policies (usually referred to as Juke's Report) discussed in some detail the relevance of corporate planning to water authorities. It was appropriate that the evolution of corporate planning in the industry should be examined after four years.

The author stated (p.1 6) that the planners' duty was to provide a logical framework and factual information on situations and consequences as guides, and major input to this process of decision making. This process involved the analysis of alternatives with the object of narrowing the area of uncertainty. The factors to be considered in such an analysis were information, alternatives, and preferences. Information was often unreliable and frequently had to be analysed mathematically to improve it. If the mathematical techniques were sophisticated, great care had to be taken in interpreting the processed data or they might be misunderstood.

Alternatives usually became evident by the consideration of the options available for the solution of a problem. Commonly, one sought to

keep all practical options open and to defer making a decision as long as possible.

Examples of preferences were whether a short term or long term view on a particular problem should be taken, and the test rate of discount for economic evaluation of alternative strategies. If the strategies were long term, then there was no reason to alter the Treasury test rate; but if a decision was to be taken on a scheme in which resources could be used in the near future, then there could be a strong argument for lowering it to say, 5 per cent if selection of the scheme would utilize manpower at a time of high unemployment. Ideally, the planner should use a range of discount rates so that the sensitivity of the analysis to the discount rate could be determined.

Water authorities had now prepared medium term plans and capital investment programmes covering five years which were rolled forward annually. Recently, it had been agreed that the long term plans which covered the 20 years required under Section 24 of the 1973 Act, should be combined with the medium term plans. In future, therefore, each water authority would produce a single plan for 20 years, which would cover five years ahead and provide a comprehensive, long term look across the whole range of the authority's functions. These plans would be prepared annually. They would contain the key information about the authority's services and, from time to time, would be augmented by strategic studies of particular water services in accordance with the needs and priorities of each authority.

At national level the White Paper entitled "The water industry in England and Wales: the next steps", published in July 1977, stated that one of the main tasks of the proposed National Water Authority would be the preparation of a national strategy for all water services; in other words, a corporate plan for the water industry. The issues referred to earlier as being appropriate for national analysis would form part of the national strategic studies which would have to be collaborative in order to be meaningful. He did not see the proposals as a threat to regional water planning but rather as an opportunity to build on the successes of the past four years.

Finally, he wished to commend to the water industry the British Institute of Management's SPUR initiative to try to improve the UK's industrial performance. The title had been derived thus:

Strategy,
Purpose, and
better Utilization of
Resources.

It did not require much imagination to apply this concept to the water industry. All managers needed a strategy both in terms of water authority plans and consistent national policies and directives. All managers should measure performance and should develop a professional performance-improvement approach. The utilization of resources embraced the whole range of the resources of a water authority - manpower, finance, and raw materials. Thus, SPUR was relevant to the water industry, and to quote the Chairman of the BIM, 'it is an apt title because figuratively a SPUR stands for stimulus, incitement, urgency, encouragement to press forward to win distinction through achievement'.

MR. G.L. DAVIES (Southern Water Authority) congratulated the author on presenting a paper which gave not only a penetrating insight into the physical planning framework of water authorities but had also demonstrated the importance of the links with financial planning. In no other field was this more important than maintenance and replacement. The questions were the usual ones: what to replace, when, and how to pass on the cost to the consumer. In seeking to assess whether the present rate of replacement was adequate, the starting point, as suggested by the author, was to find out how fast the existing system was currently wearing out and being renewed.

Long term evaluation of replacement investment was fraught with problems. It had first to be disentangled from expenditure for other purposes. So rarely did the need for replacement alone trigger a scheme that costs, which could be rightly attributed to it, might be overlooked. A retired 3 in main was never replaced by a 3 in main. Allowing for these factors, he had found in his Authority that replacement accounted for about one-third of capital expenditure planned for the next five years. An interesting feature was that the expected proportion declined from 40 per cent in the current year to 20 per cent in the fifth year. However, experience showed that when the future arrived, actual expenditure on replacement did not diminish as projected. This was partly due to the difficulty of forecasting renewals, particularly for pipes and sewers, until they were imminent. It was only when underground assets started to give trouble that a reliable forecast of their residual life could be given. Normally, the best policy was to renew only when it was cheaper than meeting the recurrent costs of repairs and breakdowns. Planned replacement on a life cycle basis was economic only when a high failure risk was coupled with serious and therefore costly consequences of interruptions; and this was limited to special areas of capital consumption.

Turning to the means of passing on the cost to the consumer, there did appear to be advantages in developing links between replacement expenditure and the charge faced by the consumer for his physical consumption of capital assets known as depreciation. Calculating the latter on the basis of theoretical asset lives for underground conduits seemed to have serious shortcomings. It also required comprehensive asset records, some of which did not exist and had they existed might still be worthless today. Provided there was no decline in standards, except in times of economic stringency when some delay might be sound housekeeping, he argued, annual spending on renewals of underground assets could be a fair measure of depreciation. Consumers would then be charged for what they took out of the system in capital consumption as the annual average cost of replacement foreseen for, say, five years ahead. The major advantage was that anticipation would be limited to a reasonable time span rather than the 100 years or so which was believed to be the useful life of many buried water assets. Lives of that order were subject to such enormous uncertainties, with a tolerance of $\pm$ 80 per cent, that it would be imprudent and uneconomic to found a replacement investment plan on so unstable a base. In these changing times, advances in refurbishing techniques and changes in infrastructure needs alone would have a radical impact on that time scale.

MR. J.K. JACKSON (Wessex Water Authority) said that the author should be complimented on producing a thoughtful paper which highlighted the profound changes taking place in water planning since reorganization. In 1974, many people had envisaged the planning task as being chiefly concerned with water resources, but, as indicated in the paper, much attention was now being directed to water supply, sewerage, and sewage disposal which together

accounted for the bulk of water authorities' capital and revenue expenditure. Within the highly capital intensive water industry, objectives were being developed progressively in the form of standards of service with target dates for their achievement; and careful consideration had to be given to the need for the distribution of, and the timing of, expenditure bearing in mind the significant impact of capital investment on charges.

Traditionally, those within the formerly fragmented industry had been used to assessing needs for expenditure by functions, but the enlarged industry was finding it helpful to consider priorities by broad categories of purpose grouped under the general headings of "maintenance", "growth", and "improvement".

Comprehensive policies on maintenance would be likely to take some time to develop, since at present there was a marked lack of information about the age and condition of buried services. The NWC Standing Committee on Sewers and Water Mains had sounded a warning as to the possible magnitude of future maintenance and replacement problems, but the real picture was likely to remain clouded until the water authorities had progressed further with their surveys of sewers and water mains.

Forecasts of growth in the context of throughput were being reviewed in the light of changing circumstances, and the author had played a leading role in the downward revision of demand forecasts for public water supplies within the Severn-Trent region. The most recent forecasts for the Wessex region were to the effect that during the last quarter of the century there might be an overall increase in public water supplies equivalent to only about 40 per cent. This represented a significant reduction in previous forecasts and clearly there would be a need to keep forecasts under review.

An area warranting discussion was that of standards of service. Improvements were necessary wherever standards of service were found to be below those required by the consumer, and the author's comment to the effect that there was little call for major expenditure on water supply improvements in the Severn-Trent region had been noted with interest. This was in marked contrast to the Wessex region where deficiencies in distribution systems had been highlighted during the drought, and where the predominantly rural nature of the supply area rendered the business of improving the reliability of supplies costly.

Recent experience had shown that in the field of public water supply, reliability had to be measured at the consumer's premises, and this meant that consideration had to be given to the frequency with which consumers should be put to the trouble of restrictions on the use of water. Wessex was formulating plans to meet certain standards of reliability of water supply and in regard to sewerage and sewage disposal, a standard of service had been found in the extent to which housing developments were held up at any time due to inadequate sewerage and sewage disposal facilities. Clearly there were many avenues to be explored in relation to standards of service over the wide field of water authority activity and the exchange of views was important.

MR. J.D. PERRET (Thames Water Authority) commented on the attempt to forecast future requirements for maintenance and renewal by considering past investment patterns for the industry (Fig. 3). He sounded a note of caution on two accounts. Firstly, the relatively high expenditure in recent years

already contained a large element of maintenance and renewal, which should cancel out the apparent requirement to replace earlier investments. Secondly, it was extremely difficult to express earlier investment in terms which made sense today. For example, the actual cost of providing a large sewer beneath a busy high street in a large town could not simply be multiplied by some factor expressing an average increase in costs in the intervening years. The original work would have been extremely labour intensive, and carried out in open cut by diverting horses and carts from the high street. The replacement cost of the sewer would have to allow for some alternative system, as yet undesigned, perhaps involving a deep heading.

As a second example, it would be interesting to speculate on how the cost of laying trunk water mains from Wales to Birmingham should be updated. The work was carried out at a time of high unemployment when would-be labourers flocked to work sites and those who were successful and who found work were content to work all day and sleep at night in the pipes which were waiting to be laid. The answer was likely to be that there were no short cuts: the only reasonably accurate way to estimate future maintenance and renewal requirements was by obtaining sufficient information about the extent and condition of existing installations. In this way, account could be taken of technical obsolescence, which could be just as important as replacement needs due to wear and tear.

MR. R.C. STEINER (Welsh National Water Development Authority) had been repeatedly struck by the fact that the topic of "priorities" was one that needed definition by real working examples. When were priorities going to be confidently spoken about instead of pale allusions being made to incomplete considerations? So much of what was said and written described what had not yet been decided. This feebleness extended far beyond the topic of priorities in the water industry. Contributors to symposia should be much more positive in the intellectual discussion of the problems of the industry and in the setting of the industry's course for the future.

As an engineer who was mostly occupied with demand forecasting and therefore planning problems, he had paid particular attention to this first paper and found much that was of interest and value. He appreciated the clear expression of ideas which were only slightly illumined by others and the wide-ranging concern for planning issues in water services. However, broad statements and generalizations did not solve planning problems. The skeleton of planning now needed to be clothed. The matrix of types of demand and consumers was concrete enough, but a framework for data was needed in order to make plans, as were collection and quality control of that data, the appropriate use of data, and last but not least, the feedback to assess the value of the data. Planners needed more to work with than just good ideas. The matrix would help to bridge the gap between management and operatives only when there was the facility to give specific information to those who planned.

The industry was not yet talking even seriously about the assessment of demand for improved environmental standards, the effects of pricing structure and trade effluent charges on the demand for metered supplies, or the recording or analysis of asset lives. With respect to environmental improvements, to write that the 'exact level which is desirable or necessary has not yet been determined' was vague and disappointing and little short of immoral, unless it was confidently expected that such a level would soon (or ever) be determined. Time had run out for that sort of allusion, and it

now had the credibility of an overstatement of what was not being done.

However, the results of exercises like the Severn-Trent Water Authority's comparative study of demands at Mansfield and Malvern were the real rocks of the industry. The water industry should be better organized now in knowing its planning requirements, nearly four years after reorganization.

In conclusion, he said that before beginning to plan, there was a need to know the truth. He was looking for the truth and hoped he would find it in the symposium papers and in the contributions to the discussions.

MR. S. SHAIL (Sunderland and South Shields Water Company) said that it was essential that depreciation provisions were realistic and this implied the depreciation of assets on their current values. This view was reinforced by the general movement toward current cost accounting. The adoption of a policy of depreciation charges based on current asset values could have a serious impact on water charges and it was important, therefore, that correct depreciation charges should be used in practice. To do this would raise many fundamental questions.

Had depreciation bases been too conservative in the past? With historic cost depreciation, the effect of using estimated lives of assets which were too short was not serious. This would not be so if current asset values were used, and it would be necessary to estimate asset lives more accurately.

Were there some assets which need not be depreciated at all? For example, the dam of an impounding reservoir should have an indefinite life, if it was of modern construction and was maintained properly. In this context, the relationship between expenditure on maintenance and expenditure on renewals would need to be explored.

Should full depreciation be charged on works when current consumers were only receiving a part of the full benefits which would accrue when the works were operating at their full output? It might be some years after commissioning before a new sewage works or water treatment plant was fully utilized.

How was new technology to be reflected in depreciation policies? Many miles of underground metal pipes might well be replaced by plastic pipes at the end of their useful lives. Many other assets would not be replaced when they were worn out: their function would be continued by the use of different methods.

All provisions for depreciation were paid for by the consumer, and consumers were entitled to full explanations of increases in charges, including those caused by increases in the amounts set aside for depreciation. The industry had a task in educating the public and the politicians to an awareness of the reasons for proper depreciation provision.

All of these problems called for a combined approach by engineers, scientists, accountants, and economists, and it was hoped that before recommending depreciation policies for the industry, the National Water Council would open the subject for discussion by members of the different professions involved.

Author's Reply to the Discussion

MR. J.E. THACKRAY in reply to the points made by Mr. Saxton, agreed with the way he welcomed the acceptance by government and in the industry of the rolling together of medium and long term plans so that there was no artificial separation between short and long term decision making, or reversion to the unsatisfactory process of producing set-piece plans at infrequent intervals and after much consultation. These usually turned out to be out-of-date by the time they were finally agreed and published. In contrast, the water authority's planning developed continuously in consultation with local authorities and others and, as a result, it was continually adjusted and brought up-to-date so that it was possible at the same time both to stick to a theme and to develop the articulation of a theme as the future merged with the present and as experience increased.

The effect of planning would be, the author hoped, to modulate the sharper peaks and troughs, illustrated in Fig. 3, except those which occurred during dire emergency, such as the two World Wars, when in effect planning might enable the troughs to be reached more quickly in the national interest. In general, an optimum working environment was only created where planning introduced some consistency into expectations of the future without solidifying them into a rigid view which could not change and develop.

In reply to Mr. Taylor, he underlined the fact that the figures in Table I were merely to illustrate the sort of role which the water industry could be asked to play, and its size and shape in relation to other similar-sized industrial concerns. For a more detailed analysis, one would have to turn to the NEDO Reports and other similar works. Mr. Taylor was right that some major studies into renewals would be needed in each water authority, and this was certainly being initiated already in Severn-Trent: he expected that similar steps were being taken in the other water authorities. The identification of this as a major issue was one of the successes of the regional authorities, even though he did not personally accept many of the particular figures currently in circulation. He did not accept Mr. Taylor's suggestion that at present, or for a decade or so, the industry would benefit from greater national consideration of most of the issues he outlined. It was essential in these matters to avoid the problems of excess grossing together of incompatible statistics on the one hand, and of too fine detail on the other. Mr. Taylor would not be surprised at the author's view that the water authorities were about the right size and were organized in the right way, both centrally through the National Water Council and regionally through their authority members, to meet the current and reasonably foreseeable needs of consumers and the environment.

He agreed with Mr. Taylor that the analysis of alternatives with the object of narrowing the area of uncertainty was one of the major tasks facing all planners, and he was interested in the reference to the BIM/SPUR initiative in this context.

He particularly welcomed Mr. Davies' contribution on renewals. The question was important for both physical and financial planning and, in his view, the key to realistic forecasting was to keep the forward forecasting period as short as possible. In this context, linking depreciation provisions to forecast renewal investment over a five-year period had strong practical and analytical advantages. He was a member of the Industry's Working Party on Current Cost Accounting and had put proposals before that Working Party which were similar to Mr. Davies'. It was, in his view,

important that the industry did not exaggerate the rate of depreciation of its assets and unduly accelerate its charges, particularly as he suspected that those areas of the industry in the UK which were still under local authority control were using lower effective depreciation rates because of their method of accounting through loan charges and because of the delayed impact of inflation on that method of accounting.

In replying to points made by Mr. Jackson, he reiterated his view that priority was determined by the planning gap for the particular service or purpose, and that intrinsic priority could not be given to broad categories of purpose under headings such as those suggested by Mr. Jackson, attractive as this generalized classification might be in presenting issues to people who were relatively remote from the industry.

The issue of standards of service was an interesting one which would be increasingly critical for the industry over the next five or ten years. Most water authorities were at present introducing equalized charges throughout their areas. This would tend to lend force to call for equalized standards of service, irrespective of the manifest difference in the unit cost of supplying those standards in rural and more intensely developed areas. The industry might have to consider either graduated standards of service on the one hand, or graduated scales of charges on the other, or some combination of the two. The relatively clumsy alternative was some form of extension of the present limited subsidies on rural provision of infrastructure which were made from Government funds.

He thanked Mr. Perret for a valuable point made in relation to the assessment of renewal needs by looking at the rate of past investment. He would try to ensure that in his calculations of future demands for this type of action, due account would be taken of the renewal which had been continuously undertaken in expanding the service in the past. Mr. Perret was right to point out some of the difficulties of comparing the costs of past investment which had been made under quite different socio-economic conditions from those which prevailed at present. However, he had often held the view that planning existed to at least attempt to tackle what was nearly impossible. In the context of estimating depreciation mentioned previously, he had drawn attention to the misleading answers that would be arrived at if it was merely assumed that every part of the system would be replaced like with like. The accounting profession was aware of this problem and the detailed proposals for current cost accounting put out by the Morpeth Committee had suggested that in circumstances such as the Elan-Birmingham pipeline that it should be estimated with the cost of replacing with a 'modern equivalent asset'. This would probably turn out to be some river regulation scheme.

He welcomed Mr. Steiner's comments on the value of the planning data being derived by studies of domestic water consumption. The Authority's current Corporate Plan, *To 1983 and Onwards* which could be obtained from the Authority on request, showed reasonably exactly what was being planned in terms of environmental improvements and the estimated costs of making these, which altogether led to charges on consumers in the Severn-Trent area of about £6 per annum per household.

Mr. Shail's contribution about accounting for the effects of inflation was welcome. He himself was sceptical about the concept of estimating asset lives and the proportion of an asset used in any one year as having much relevance to the water industry. It was interesting to note that in the

railways, to the best of his knowledge, the original costs of embankments and tunnels were not written into the accounts and fixed assets were defined as rolling stock, stations, and other items likely to be replaced in practice, rather than to be continuously maintained. For the water industry, he had already given his view that the best thing was to link depreciation provisions to planned investment on renewals. This would provide realistic answers for any but the smallest concerns where renewals investment might be rather lumpy in character. Even there, a five-year smoothing of renewal requirements would iron out quite major peaks and troughs in the required investment profile. The answer to the problem of making sure that changes in technology were adequately reflected in depreciation policies was to allow, wherever possible, for replacement costs to be based on the cost of a modern equivalent asset, although here again the renewals approach short-circuited this problem. The National Water Council, with representatives from the water authorities and the water companies, was already undertaking work of the kind called for by Mr. Shail, and being a member of that Working Party the author would be pleased to supply him with an up-to-date view of the position on request.

2. FINANCIAL PR OBLEMS

E.J. Gilliland, IPFA *

INTRODUCTION

The financial probl ems in water services, particularly in the past few years, have tended to be very similar throughout most developed countries irrespective of the systems of financing adopted. These problems in particul ar relate to increases in charges in real terms (i.e. above the going rate of inflation), inadequate depreciation, borrowing and re-borrowing at higher interest rates, replacement of outworn and obsolete assets, and the demand for capital investment in excess of available resources.

In examining some of these financial problems from the point of view of Water Authorities in England and Wales, their particular economic and governmental environment must also be considered. It is in the main the difference in these environments that result in differing solutions being proposed or adopted in different countries.

One of the principal causes of some of these problems arises from the fact that water services are, however measured, one of the most (if not the most) capital intensive of all industries, and certainly of all public utilities (with the possible exception of telecommunication). Thus such financial problems as resource allocation, depreciation, and borrowing are more important in the water service than they are in a labour intensive industry.

Before considering some of these problems in more detail, it may be as well to look at the background both pre- and post-reorgani sation.

BACKGROU ND

Historical

Prior to reorgani sation in 1974, the methods of financing water servi ces in England and Wales had seen little change since before the turn of the century. Despite at least some limited reorgani sation, post 1945, in the amalgamation of small water undertakings and to a lesser extent of drainage authorities there had been no revolutionary changes in their methods of financing. Developments in the introduction of more effective charging policies and tariff structures in other countries were for a variety of reasons largely ignored.

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Capital Finance. In the field of capital finance almost all capital investment incurred was subj ect to loan sanction procedure, i.e. approval by the appropriate Government Department. This generally meant in turn that each scheme or proposal was considered entirely on its own merits and without regard to implications elsewhere or to regional or national priorities. It is accepted that the appropriate Government Departments should have had regard to overall national strategy and objectives and from the mid 1960's this was increasingly the case. Nevertheless, the fact remains that so far as individual undertakings and local authorities were concerned, once loan sanction approval for a scheme had been received, then that scheme, as originally outlined and designed, was generally implemented.

Apart from limited u se of repairs and renewals funds by some undertakings, and even more limited use of specific contributions from revenue account to capital outlay, all capital investment was financed from borrowing. This borrowing was considerably flexible with short term loans, stocks and bonds being raised as well as the more conventional types of loans.

Once having borrowed the money, predecessor authorities were faced with a choice of either setting up sinking funds into which contributions were made from income received each year in order to ensure that there was sufficient money in the fund at the end of the loan repayment period to repay the loan, or alternatively to operate a loans pool whereby borrowing did not necessarily relate to the specific lives of assets concerned, although the charges to revenue generally had regard to the lives of the assets being provided.

Revenue Finance. The method of financing revenue expenditure varied between the services concerned. Leaving aside the smaller services such as water resources, land drainage and recreation and amenity, the charges for the provision of water supply were based either on consumption by means of measure; or related to the property value (net annual value). In the case of non domestic consumers who were not charged on a measured basis, some rebate from n.a.v. was given to reflect the recognition that the quantity supplied bore little or no relationship to the value of the property. For sewerage and sewage disposal, apart from trade effluent charges which were levied by the majority, but not all authorities, the cost of the services provided were met in part by a non-specific government grant (Rate Support Grant) and the balance from local taxation through the rating system. In consequence all rate-payers paid something towards the cost of sewerage and sewage disposal irrespective of whether or not a service was provided to the ratepayers concerned. Furthermore it should be noted that charges were paid according to the basis of the value of the property, and not on the basis of the cost of providing the service.

Post-reorganisation Changes

Apart from general changes arising from reorganisation, there was a number of specific changes enacted in the Local Government Act, 1972 and the Water Act, 1973 relating to finance which are of relevance to this paper.

Capital Finance. Firstly so far as capital investment is concerned changes include:

(i) The cessation of the issue of loan sanctions. Instead an annual capital investment allocation is given to each Water Authority. At the present time the allocation is given in specific survey prices and within that allocation and subject to certain constraints between different services each Water Authority is free to decide on its own priorities between competing schemes.

(ii) A firm commitment to an annually revised 5 year rolling programme of developments is required by the Water Authorities and the Government Departments concerned.

(iii) Borrowing which can only be incurred in respect of capital investment is limited to 3 specific areas. If it is in sterling it can only be from the National Loans Fund for a fixed period of time, generally related to the average life of all assets of Water Authorities, at a fixed rate of interest. In addition, foreign loans can be raised with the approval of the Treasury and the Bank of England, and to this end Water Authorities have been successful in raising 3 foreign loans during the first 3 years of their life. A further aspect of foreign borrowing is available to some Water Authorities through the EEC and in particular through the European Investment Bank. This, however, it should be noted, is limited to certain Water Authorities, and only for certain types of schemes.

(iv) Since the 1st April, 1976 cash limits have been applied to the capital investment of Water Authorities. For the years 1976/77 and 1977/78 these limits are placed upon the amounts that can be borrowed by Water Authorities. At the time of writing discussion is still proceeding between the Water Authorities and the Department of the Environment as to whether cash limits should continue to be applied on borrowing, or whether they should be applied instead to the annual capital investment allocations.

(v) Arising out of Government acceptance of agencies for some functions it should be noted that some 35% of capital expenditure is incurred by local authorities as agents for sewerage under Section 15 of the Water Act, 1973, although it is financed by the Water Authorities. Furthermore capital expenditure of water companies is not subject to the same control as Water Authorities. This is an artificial division between public and private expenditure, applied by the Treasury. Eight of the ten Water Authorities have between them 28 water companies acting as agents for the supply of water. Now these water companies, being companies subject to the Companies Acts, are regarded by the Treasury and the Government as part of the private sector. Under the terms of their agency agreement companies are only required to submit to their principal Water Authority details of large scale items of capital included in their programme for the purpose of enabling the Water Authorities to

assess whether or not their proposals meet the twin (sometimes conflicting) requirements of optimum use of water resources and ability to meet all requirements of the agent supplier. There is thus the illogical situation that the laying of a water main to a new housing estate can be either public or private expenditure, and subject to different controls, constraints and rules, and yet achieving the same objectives and financed in exactly the same manner - through charges on either a measured or an unmeasured basis.

Revenue Expenditure and Charges. On revenue expenditure the most significant changes are enshrined in Sections 29, 30 and 31 of the Water Act, 1973 (as amended by the Acts of 1976/77). These are:-

(i) Section 29(1) requires every Water Authority to break-even, i.e. to ensure that taking one year with another their revenue "is not less than sufficient to meet their total outgoings properly chargeable to revenue account". I would draw particular attention to the words "outgoings properly chargeable to revenue account" because this is a matter to which I would wish to return later.

(ii) Under Section 29(2) the Secretary of State has power to give a direction either to an individual Water Authority or to all Water Authorities with a view to securing a rate of return on the value of the net assets used by the Water Authorities.

(iii) In addition Section 29(2)(b) is drawn wide enough to place the Water Authorities in the position of being under any other financial obligation that the Secretary of State may think fit to impose through the issue of a direction.

(iv) Section 30 deals with charges, and in particular sub-sections (4) and (5) have changed completely the bases of charging for water services to one whereby Authorities are required to charge their customers only for services or facilities provided, while having regard to the cost of providing those services, and without unduly discriminating between different classes of customers.

Implications of Changes

Much has been written and said already about the implication of these changes both managerially and socially.

Changes in capital investment with the emphasis on integrated physical and financial planning, investment appraisal and priorities are matters worthy of more detailed consideration and I propose to return to this subject later. Changes in revenue financing, and in particular changes in charges and charging schemes, are a subject entirely in their own right. A great deal of work has already gone into the considerations of methods of implementing Section 30, and apart from 2 Jukes Committee reports (1) and (2) and the

National Water Council's report "Paying for Water" (3), there have been many seminars and articles on the subject and I have no doubt there will be many more before the final deadline of the 1st April, 1981 arrives. I do not at this stage propose to say much more except to comment that the implications of Section 30(4) and (5) were never understood either by the then Government or their advisers, or by Parliament when Section 30 was being considered. In consequence the potential problems, including some that have arisen already (e.g. Daymond and Cesspit Charges), are still not completely understood or appreciated and the implications of change in incidence in charges are only just beginning to be appreciated.

FUTURE FINANCIAL PROBLEMS

Thus there exists a situation whereby, apart from the inheritance of some financial problems, including charging on the basis of historic cost, others have been created by reorganisation and others have arisen because of the economic climate in the past 5 years.

There is furthermore a situation whereby demand for investment is generally in excess of the limited capital resources available, and a general air of public expectation of the highest possible standard for all without having regard to the realities of the situation.

It is the demand for new or improved services or even just the maintenance of the present ones, which create the plans and programmes of Water Authorities, and which in turn are later translated into increased expenditure and consequently charges.

Capital Programmes and Appraisals

The requirements of Section 24 of the Water Act, 1973, and in particular sub-section (6) with its emphasis on planning and programming on an annual basis is, I believe, a recognition of the importance of ensuring that investment strategy and programmes are expressed not only in physical terms (including quantifying outputs and standards and identifying social/economic costs) but also in financial terms. Not only is this a means of ensuring that the plans and aspirations have to be met through capital programmes and later through charges, but it is also recognition of a need to ensure that governmental control on capital investment is achieved without too detailed an interference in individual programmes.

A considerable amount of discussion and effective work has now gone into providing the outline of Water Authorities medium term plans covering periods of 5 years. As all are aware these are rolling programmes which are reconsidered by each Water Authority and re-submitted to appropriate Government Departments annually.

The form and content of these medium term plans and programmes are on an integrated basis. Integrated because the information of the plans help to

meet the needs of both the Public Expenditure Survey Committee process and the legal requirements of the Water Act. More importantly they are also integrated because the need to reconcile physical, economic and financial planning has been recognised and developed.

Apart from these advantages, there is the added advantage that the process of resource allocation within each Water Authority has been considerably strengthened by the consideration of these programmes, as is the awareness of the impact of government and local authority plans and programmes on the priorities and work of the Water Authorities.

Project Appraisal

Turning from the broader spectrum of capital programmes to the problems of individual project appraisals, it goes without saying this must include an economic and financial appraisal, using present value methods of discounting future expenditure. The use of the Treasury test discount rate for project appraisal in nationalised industries was enshrined in two White Papers of 1961 and 1967 (4 and 5) and has been "applied" to the water industry since 1974. It has up to now been honoured more in the breach than by observance, although most Water Authorities may have used it as part of their work on some project appraisals. Certainly if ever charging policies are based on long run marginal costs, detailed financial appraisals (including cost benefit analysis) are necessary if only to ensure that future charges are in line with investment policies. Even if charges continue to be based on average historic costs or "actual" costs, whatever these may be, then it is still, in my opinion, necessary to subject a considerable proportion of proposals for capital investment to such an appraisal. Sufficient has been written on this subject for me not to have to discuss it in detail; I would only comment on one small part, namely the appropriate rate or rates to be used in discounting to present value. As I mentioned earlier the use of the Treasury Test Discount Rate for project appraisal is supposed to have been applied to the water industry since 1974. There is also as I mentioned earlier the possibility of the Secretary of State directing Water Authorities as to the rate of return to be achieved on the value of the assets employed. It is perfectly possible for one rate to be in conflict with another. Certainly this would be the case if one was using the TDR for the purposes of calculating and charging on a marginal cost basis, while being required to achieve a rate of return on the current value of assets employed. There is at the present time a failure to recognise that the use of TDR and target rates of return on assets are only part of a system of control of financial obligations and objectives by Parliament. Without the integration of the other parts, i.e. capital expenditure through investment allocations, cash limits and the methods of borrowing, the present system will fail to achieve its objectives.

Financing of Capital Expenditure

Although the methods of borrowing by Water Authorities was mentioned earlier, there are in effect five main methods of financing capital expenditure,

all of which may be used at the same time. The proportions financed by different methods depend on the law, customs and usage of different Water Authorities. The five methods are:

(i) Contributions by new customers. These may be regarded as akin to an entrance fee to a club. They are sometimes termed connection charges, or tap fees, but all of them have the same principle namely that of requiring a developer, or a new customer who is connected for the first time to a system, to make a capital contribution not only for the direct new service provided, but also perhaps to some part of the costs of the existing system. This contribution may be either in cash or in the provision of the physical service, or may take the form of both.

(ii) Government grant towards capital costs. These grants of a capital nature are generally used to encourage the implementation of policies which it is felt will either impose too heavy a burden financially upon existing customers and/or the community, or are necessary to ensure a minimum national standard of service. So far as Water Authorities are concerned they are of an extremely limited nature and apply only at the present time to rural water supplies and sewerage, and more especially land drainage.

(iii) Loans. These have been covered already.

(iv) Self Financing. This I would define as a proportion of capital investment financed from annually (or periodically) generated surpluses. These not only arise from deliberately planned surpluses, but also from the excess of depreciation charged over debt repayment liability. These funds are used as a means of reducing reliance on external borrowing and loans.

(v) Specific revenue contributions to capital. In the water industry these sometimes masquerade under the guise of renewal and replacement funds or plant replacement funds, and are often regarded as a means of evening out the financing of certain identifiable parts of a capital programme.

Leaving aside (i) and (ii) if only because in fact they are at this time of limited significance to Water Authorities, one is left with three other methods generally in use.

My firmly held preference is for a mixture of loans and self-financing and not for specific revenue contributions. My reasons are the greater flexibility this gives for overall financial management of capital programmes, and if a firm commitment to a ratio of self financing of between 40% and 60% of capital requirements is set, it introduces a greater element of financial discipline into the consideration of capital programmes. If charges cannot be raised to provide an increase (in real terms) in the amount required for self-financing purposes, then the programme needs to be examined in the light of the known reaction from realities of the situation. The continuing reliance by some Water Authorities on loans for 90% or even more of capital investment

programmes must sooner or later bring about a situation where essential capital works are inhibited from introduction because of the size, real or imaginary, of the annual burden of debt charges, and the ever increasing proportion of revenue expenditure that this takes.

The provision of replacement and renewal funds I dislike because of the implicit acceptance of earmarking certain items of capital for a different method of financing, and thus tacit acceptance that depreciation policies have not been as effective as they should be. Of course a move away from substantial loan financing to self-financing must initially and inevitably mean some increase in charges, if these are calculated by reference to historic or actual costs.

Effects of Capital Expenditure on Revenue Requirements

Apart from capital contributions and Government grants, the other three methods of financing capital expenditure just discussed have an impact in four ways on revenue expenditure and consequently upon the revenue required.

These are interest on loans raised or capital employed, depreciation, debt financing (sometimes mutually exclusive to depreciation) and either specific revenue contributions or planned surpluses for self-financing.

During reorganisation there was considerable discussion on whether or not Water Authorities should be required to achieve a specific rate of return on the value of net assets employed. Although, as mentioned earlier, there is legal provision under Section 29(2) for the Secretary of State to introduce such a requirement it has not so far been operative. A similar concept has however been used in respect of some of the nationalised industries, e.g. gas, electricity, railways, etc., but over the past ten years it has not been applied consistently. The arguments for and against such a concept are lengthy, but are well summarised in a report entitled "Water Services - Estimates and Accounts" (6). I do not propose to deal in more detail with the views in this paper except to make two short observations. Firstly, such a concept in my view fits in much more neatly with marginal pricing policies based on LRMC than with the more universally used method of charging on average or historic costs. In consequence, I fail to see how it can be argued by some economists that it is not right to require a return on assets and yet it is right to use LRMC for pricing purposes. Secondly, it would be much more appropriate if current cost accounting was in use and the current value of assets was known and a rate of return on this value was required to be shown.

If a return on capital was not to be a statutory obligation then interest at least on external debt will fall to be paid. However, interest rates vary over time and I can see no merit in charging particular expenditure with rates of interest that are current at the time they are incurred. In my view, given a realistic depreciation policy, all services should be charged interest on the written down value of the assets in use during a particular period in time. This rate should be the average rate of interest on external borrowing calculated

yearly. To the extent that these rates are in excess of the actual amount of external interest paid, reflects the fact that some assets (or parts thereof) have been financed out of reserves and surpluses as well as out of borrowed money. Only if interest is charged on this basis to all assets, however financed, can a realistic charge be made to consumers for the use of assets provided. Any surplus on the interest account can of course be utilised for further self-financing.

The question as to whether to reflect in revenue expenditure the principal element of laons raised to finance the provisions of capital assets or to provide depreciation is one I know where there is much to be said on both sides. My own opinion is that depreciation is not just an accounting convention. It is the mechanism by which the cost of the economic use of assets is charged in a revenue account before a surplus is declared. It is the amount of expenditure which should reflect the use made, that is the physical consumption of assets provided during an accounting period; and the written down value of assets should approximate to "the real net value". Given reasonable cash flow management, depreciation policies ensure that the funds needed for eventual asset replacement are generated automatically. This, of course, is on the assumption of the maintenance of constant prices and that the original asset would be replaced by an identical new one.

Whether or not sinking funds are used in connection with loan charge provisions is to my mind irrelevant. In neither case can the most appropriate charge for the use of assets be reflected in the accounts. This can only be done by the adoption of depreciation techniques across the board for all assets however financed. Provided that realistic depreciation policies and schedules are agreed and developed, then the resulting expenditure will reflect more appropriately the method of charging for the use of assets. Depreciation charges based upon replacement costs will generally be in excess of the capital servicing required, but this again is no bad thing, because in consequence any surplus can be utilised for its proper purpose of self-financing, thus containing the overall debt of the organisation.

The question has sometimes been posed, 'is a realistic depreciation policy such as has been advocated and adopted generally by Water Authorities better than debt charges and inadequate sinking funds with their need to reborrow?' In my view the answer must be yes - provided that depreciation policies reflect national accounting standards on inflation accounting or depreciation is charged on a replacement cost basis. Again one comes back to the view that if prices are on long run marginal cost bases, and these are reviewed to take account of the replacement cost of assets on which these costs are calculated, there is not the same problem as there is with a system of charges based on historic costs. It is only by adopting such policies that the problems of replacing aged and worn out assets can at this time be viewed with any optimism.

Current Cost Accounting/Inflation Accounting

On the present basis of the amounts charged to revenue account with their

emphasis on finance capital rather than physical capital, there is in my view clear evidence that historic costs are not recovering the current cost of providing the water services. As mentioned earlier the view of many economists is that in order to achieve economic efficiency in the provision of services, long run marginal costs should be the basis of pricing policies. I would like to offer a counter view which is that given a proper application of current cost accounting, with realistic depreciation on the current value of assets and a target rate of return on that value (say $2\frac{1}{2}\%$), then charges would more nearly approximate to current costs and probably to long run marginal costs.

It has been suggested that this would require an increase in charges initially which could be regarded as self-inflationary, I do not hold completely with this view. My own opinion is that for some years since inflation rose into double figures there has been a clear indication that in real terms many customers have been paying less and less for their services with the consequence of stimulating excess demand and building up problems for future generations.

I am a firm advocate of the adoption of current cost accounting with a target rate of return on the capital value of assets for three reasons:-

(i) The charges reflect the current economic costs of providing the services. They are neither below nor above these costs. Consequently demand for services should be much closer to economic reality than they are at the present time. The great danger at the moment is that with charges clearly being below economic costs or marginal costs, there will be a continuing increase in demand for services above what economically is most viable and most efficient.

(ii) There is an introduction of financial discipline, with the ability to provide a greater measure of self-financing. At the same time there is a movement from the finance capital concept to a concept of the use of physical capital while ensuring that there is an appropriate rate of return on it.

(iii) Finally, the ability of the Water Authorities to achieve target rates of return can be clearly demonstrated. Their achievement of, or failure to achieve, objectives set can clearly be stated and understood, with at the same time a much more ready awareness by the public as to the amount of capital actually employed in the provision of these essential services.

THE IMPLICATION FOR CUSTOMERS

Whether or not current cost accounting is applied, it must be accepted that a greater measure of self-financing with a more realistic depreciation policy would mean some increase, with or without the introduction of long run marginal costs, in charges to customers. To the extent that they may only be reflecting current costs as opposed to outdated historic costs may be beside the point when it comes to implications for individual customers.

Leaving aside the problems of changes in incidence arising from the application of Section 30 of the Water Act, which in itself will have an impact of some increases and decreases in charges both between and within classes of customers, there are other implications for the individual customers. At the present time the system of charges, without universal metering to all customers, means that the great majority of customers served have no means by which they can influence the amount to be charged for that service. Even those who advocate marginal pricing policies recognise that these policies can only be effective in an economically efficient way if the customers concerned have a means of influencing the charges to them. In almost all Water Authorities there is a proportion between 35% and 45% of their costs which are standing costs and would not necessarily fall to be recovered under marginal pricing. Marginal pricing of necessity assumes an ability by customers to influence charges and this I would suggest can only be done by means of measured consumption charges.

Even if as suggested by the National Water Council Working Group on Charging Policies that volume related charges (i.e. by measurement) should apply to all water services so far as all industrial and the majority of commercial properties are concerned, the question may still arise and still has to be answered as to the extent to which such charges may have any practical values in affecting demand and effecting changes in the provision of services.

Given that at the present time the charges to the majority of domestic customers who are not measured for all water services is under 1% of their average household expenditure, it is a matter of considerable debate as to whether there is any elasticity of demand which might be reflected should they be put onto a measured basis. But even if they were not, and given that there may be some increase in real terms in their charges over the next ten to twenty years, with the present low proportion of average household expenditure, is there a case for considering the argument that services should be cut according to available income? We have seen during the drought the fact that people may be willing to pay almost any price for a service, although at other times the price that they would be willing to pay will be considerably less. However, I would suggest that the majority of people in this country still today would prefer to pay slightly more for a continuation of the existing service.

Nevertheless, there are still problems of priorities. These problems on priorities however arise more because the present demand for services exceeds the total amount of resources available to meet them. The development of priority rating systems by individual Water Authorities, and more especially the continuing work on objective analysis of 5 year development plans by the Department of the Environment and Water Authorities should greatly assist in these areas.

CONCLUSION

It has unfortunately not been possible to deal in depth with some of the

financial problems mentioned earlier. The Water Authorities have I believe made great progress in solving some of their inherited problems, and have learned to live with but not necessarily accept some of the more doctrinaire changes introduced by the Water Act, 1973. The next 5 years will be a testing time for all concerned with finance in the water industry because the solutions to such problems as inadequate depreciation, rising costs of replacement, and changes in charging policies must be solved if the industry is to remain credible in the eyes of the public and Parliament.

REFERENCES

1. Department of the Environment, 1973,"The Water Services: Economic and Financial Policies", First Report, H.M.S.O.

2. Department of the Environment, 1974,"The Water Services: Economic and Financial Policies", Second Report, H.M.S.O.

3. National Water Council, April 1976, "Paying for Water", A discussion of economic and financial policies for the water services.

4. H.M. Treasury, 1961, "Financial and Economical Obligations of the Nationalised Industries", Cmnd. 1337.

5. H.M. Treasury, 1961, "Nationalised Industries - A Review of Economic and Financial Objectives", Cmnd. 3437.

6. Department of the Environment, 1974, "The Water Services - Estimates and Accounts", H.M.S.O.

DISCUSSION

Author's Introduction

MR. E.J. GILLILAND introduced the paper by saying that when he had been considering the scope of the paper in relation to the theme of the Symposium, he had been struck by the width and range of financial problems and had been concerned as to which of these problems should be dealt with in any other way than superficially.

Before going on to some of these matters in more depth, he commented on the theme printed in the preface to the Proceedings. He did not have any quarrel with the first paragraph. However, the second paragraph raised some doubts in his mind. The phrase '... such problems as whether financial and

economic objectives accurately reflect engineering and scientific realities ...' was the one with which he took issue. He suggested that all those in the water industry must be aware of the present economic realities, both in this country and elsewhere, and should be demonstrating that they were in touch with these realities and the general expectations and situations of customers. In other words, the industry's attitude should not contain either the arrogance of the old saying "we will provide what we think is right for our customers, because we have always operated this way" or the sentiments of the present saying, "it cannot be done, except at a price, but the Government will not let us spend it". The water industry had to develop and integrate the physical planning with both economic and financial planning, possibly further than had been in the past.

He had suggested in the paper that the economic and financial problems of the water industry fell into three broad categories:

1. those of an inherited nature, including coping with the problems of reorganization;

2. those arisen from the state of the economy including high levels of inflation, shortage of capital funds and resources, which had been particularly acute during the past 4 or 5 years; and

3. those arising from the Water Act, large and some small, including the whole philosophy of how the water services should be financed and paid for!

Of course, there was a fourth problem: that of coping with decisions, both informal and otherwise, which came from Westminster, Whitehall, and Queen Anne's Gate, as well as advice which came not just from the Press but also from academics. How to cope with these problems was not, fortunately, part of the symposium.

Of the three major problem areas, he did not say much more about the first, except for one small tribute. He believed that the water authorities had managed to overcome the financial problems of reorganization much better and much quicker than either local government or the health service, despite having inherited a woefully weak and totally inadequate number of finance staff. Much of the staff work in this area had been taken for granted and he welcomed the opportunity of reminding everyone of the achievements of the past four years.

It was in the other two areas where there was still a distance to go, and much work had to be done before there were satisfactory financial frameworks and realistic financial policies.

Mr. P.R. Herrington in his paper (p.6 1) had suggested that a consequence of the past few years was that two areas appeared to dominate the industry's managerial thinking: these were investment appraisal and the establishment of sensible and fair charging policies. If this was so, and he did not think it was, then he believed that priorities were wrong. It was no use developing investment appraisal techniques if financial policies were neither realistic nor up-to-date. As he had said in the paper, the use of the Treasury Test Discount Rate for investment appraisal was only part of a system of control of financial obligations and objectives.

In his plea for more realistic financial policies, he wanted to

include not only less reliance on borrowing for capital investment and thus more self-financing, but a development of current-cost accounting rather than accounting with historic costs.

In the late 19th and early 20th century when the water services were being developed, the industry's predecessors had concentrated on the finance concept of capital, i.e. they equated the life of the loan raised to the anticipated life of the asset, and the debt repayment was regarded as the same as depreciation. During times of low or no inflation and a low real rate of interest, there was little difference between what the Woodham Committee described as the finance concept and the physical capital concept.

The physical capital concept, which he believed today's water industry should be adopting, being one of the most capital intensive industries in the country, was a concept where depreciation was not regarded solely as a means of repaying a loan but was the charge to revenue each year (or period) which was made to reflect the economic cost of the use of the assets during that period. To take the physical capital concept further, he believed that depreciation should be charged on the net current value of assets, i.e. the written down value.

One of the effects of ever-continuing inflation was identified well in *Paying for Water* (3), where attention had been drawn to the inadequate provision being made for the renewal and replacement of ageing assets. If the view which he had advocated, as others had before him, e.g. Woodham (6) and Jukes (1)(2), was accepted, then it could be seen that charging depreciation on the historic cost of assets meant undercharging existing customers. This in turn had led to greater demand for an improved service, together with the difficulty of meeting all demands within the limited resources made available through the Capital Investment Allocations. In addition, there was the fact of different generations benefiting unequally, which fact assumed increasing importance. Apart from charging on a more realistic basis, one of the benefits of adopting this basis was a possible increase in self-financing of capital expenditure. As he had said, he would like to see the physical capital concept developed in a number of areas. Managerially, he recognized all the problems associated with arriving at a current value of assets, but he was sure a development of the exercises carried out for the report *Paying for Water* would not present too many problems. Apart from bringing more realism into charges, it would also bring an air of reality into comparative costs and statistics. The present attempts which had been made by water authorities, the NWC, and the DoE to produce interauthority statistics, or even interdivisional ones, floundered when the use and value of assets were introduced. The wide and differing time-span and costs of similar assets made such statistics both incomprehensible and useless, unless current values were used.

In his paper he had gone further in his advocating more realistic financial policies in that he had suggested that alongside charging depreciation on the current value of assets, the water industry should have a specified target rate of return on their assets. He had advanced three reasons for the application of such a target rate, with current cost accounting (p.2 10), and the more he considered these, the firmer his views became. The Government, or at least the Treasury, were busy rewriting the 1961 and 1967 White Papers on the financial and economic obligations/objectives of the nationalized industries, and he noted that three authors had referred to these White Papers. This was in response to the NEDO report on nationalized industries. He hoped that when, rather than if, the required rate of return was applied to the water industry, it should be on

current asset value. He also drew attention to another of his comments on this, i.e. that with a real return of about 2½ per cent on current asset value, the charges levied would approximate to long run marginal costs.

The author then turned to how, having arrived at the appropriate level of income required, this income was shared on a basis which most might consider was logical and fair, i.e. upon cost imposed. As he had said in the paper, charging policies were a subject for a seminar on their own. However, there was no doubt that at the moment there was a considerable amount of cross-subsidization both between and within different classes of customers. How far down the road had the individual authorities gone in identifying this? He said that it must not be forgotten that there had not been much more than three years in which to develop and implement fairer policies. He was sure that there was the technical and professional skill and enthusiasm to solve these problems in time: he was more concerned whether there was the desire or the political will to indulge in what might well be sweeping changes.

Finally, he spoke on the integration of all planning, i.e. physical, economic, and financial. If one had read only four of the other papers in the Symposium one could doubt the need for integrating financial planning. However, there could be no mistake that changes, or lack of changes, in financial and charging policies could have far-reaching effects which, if ignored during the physical planning stage, could lead to difficulties in the wrong timing and/or placing of investment. He concluded with the last sentence of the paper, because that was the essence of his message:

> 'The next 5 years will be a testing time for all concerned with finance in the water industry because the solutions to such problems as inadequate depreciation, rising costs of replacement, and changes in charging policies must be solved if the industry is to remain credible in the eyes of the public and Parliament'.

Verbal Discussion

MR. E.C. REED (Thames Water Authority), in opening the discussion, noted that in the preface to the Proceedings, the purpose of the Symposium was stated as being the study of the interface between possible economic and financial policies in water services and desirable or essential scientific and engineering policies. In other words, how to reconcile the possible, in financial terms, with the desirable or essential, in operational terms. Hence this Symposium was concerned with managing the water services as effectively as possible at the least cost. The author had given valuable guidance on how to relate the possible with the desirable.

The author had pointed out in his introduction (p.2 1) that he was talking from the point of view of the regional water authorities; their problems were of particular significance to the water authorities and could be seen to have arisen from the new legislation.

In dealing with the post-reorganizational changes, the author had set out clearly the controls on capital finance that were imposed by legislation. The Government's interpretation of these effectively removed a number of matters beyond the water authorities' control. The impact of swings in policy, such as that experienced due to the moratorium, were undoubtedly disruptive to efficient management. There were also some illogical

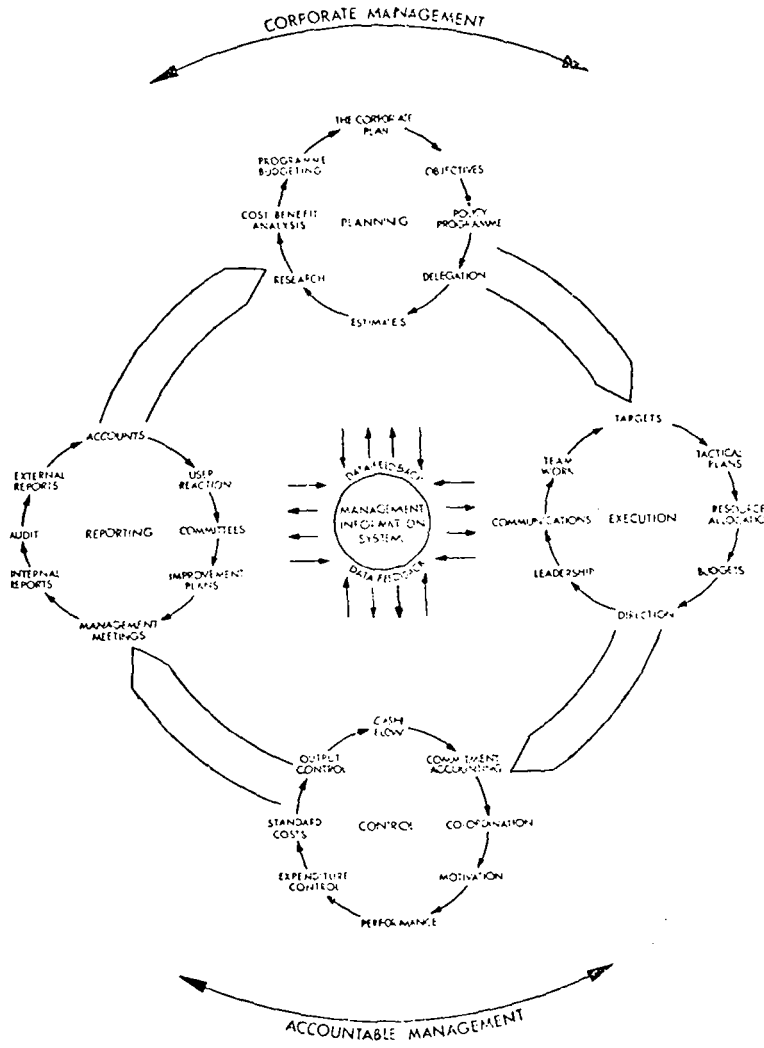

Fig. 1 The water services estimates and accounts

situations to which attention was drawn (p.2 4). An example was the differences in the costs of capital works imposed on the same class of consumer but arising from the difference between capital financing in the public sector and that defined as the private sector in the paper.

Turning to the management of the regional water authorities, the Woodham Report gave a desirable format on its frontispiece which should, if properly applied, eliminate internal interface problems. A good management information system was essential to ensure the accuracy of relevant data. This sliding of the interface between corporate management and accountable management not in the financial sense also showed the criteria for the planning cycle leading to execution, control, and reporting (Fig. 1).

The other important factor which was unresolved at the moment was the method of getting the money in, i.e. revenue charges. As the author had implied, it was improbable that the then government, or parliament, understood the consequences or problems of Section 30 of the Act, parts (4) and (5). Section 30 dealt with charges and in particular parts (4) and (5) had completely changed the bases of charging for water services to a basis whereby authorities were required to have regard to the services or facilities provided in setting their charges, while having regard to the cost of providing those services and without unduly discriminating between different classes of customers.

One of the basic principles which this clause altered was that the water services no longer operated on a public health basis, with the yardstick being the ability to pay. Instead, the basis of charge might be the cost of providing the service regardless of benefit.

On the subject of financing capital expenditure, the author's preference was not unlike his own, and that was a major move towards self-financing. In the capital intensive water industry, if continual and nearly total reliance was placed on borrowing from the NLF, then charges would certainly rise whilst the services provided would stand still. When difficult times arose, a substantial proportion of self-financing did provide considerable flexibility. The author had made the understatement of the year when he said (p.2 12) 'the next 5 years will be a testing time for all concerned with finance in the water industry because the solutions to such problems as inadequate depreciation, rising costs of replacement, and changes in charging policies must be solved if the industry is to remain credible in the eyes of the public and Parliament.' He would be interested to have the author's own view on those steps necessary to ensure that the industry remained credible in the eyes of the public.

MR. C. COLE (Ministry of Agriculture, Fisheries and Food) said that the author's reference to project appraisal (p.2 6) covered common ground between accountants and engineers. The technique had, in fact, been invented by the US Corps of Engineers. The engineers at his Ministry had been concerned with it for many years. The Government wanted to know that a project was worthwhile before supporting it, and this required some logic in support of subjective opinions. They had been concerned to know that benefits were greater than costs, although sometimes there were other kinds of justification. Water authorities now had to consider how far the use of cost-benefit analysis should be extended. Where should they operate along the line between a determination that the benefit/cost ratio was greater than 1 and a precise determination of orders of priority?

It was relevant that economic texts often began by emphasizing the limitations of economics and the prior role of political decisions. Moreover, Walsh and Williams* had said 'Cost benefit analysis does not provide the administrator with a means of relieving himself of critically important decisions ... cost benefit analysis ... is a means of organizing thought, not a means of avoiding it'; and again 'devices which appear arbitrary methods to the economist qua theoretician may be perfectly acceptable in a wider context'. Thus, there seemed to be ample support for the political and subjective element, which would cover what were sometimes referred to as intangibles. The water supply industry had served the country magnificently by a combination of good business management and sound judgment of priorities. Cost-benefit analysis gave it a new tool.

It was vital to remember that economic appraisal was not about money but about resources and, ultimately, manpower. It covered the wide area of social benefits and costs, in contrast to the limitations of financial appraisal.

There was great controversy about discounting and there was even an argument that it should be negative in times of heavy inflation; but positive time preference was not seriously questioned. He had noted the author's query about the Treasury Test Discount Rate and a rate of return set by the Secretary of State, and suggested that the two fields could be kept separate. The resources basis for economic appraisal and its emphasis on social benefits seemed to him to support this approach. Walsh and Williams had said that 'The yield of any financial asset is an inadequate reflection when a public project is undertaken rather than a private one'. However much one argued about discount rates, the underlying realities stayed the same, and he pleaded for agreement on this matter, accepting that perfection was unobtainable.

MR. D. WATSON (Central Water Planning Unit), speaking more as a consumer and ratepayer than as a professional in financial matters, expressed himself as being apprehensive at some aspects of the paper. These apprehensions arose from several years of mild, personal financial mismanagement before realizing that saving income and paying cash was a fine policy in an era of appreciating money, but was unwise when money was depreciating. This devaluation had accelerated in recent years and present instabilities in the pound, in interest rates, and in inflation gave little hope for reversal in the medium-to-long term. Even the North Sea oil optimists claimed no more than a short term improvement. In these circumstances where inflation was higher than interest rates, borrowing money, far from being a drain on profits, was particularly good business. It was strange, therefore, that the author urged the water industry to pay cash out of income, rather than to borrow. It could be that water authorities with high levels of borrowing were showing greater financial acumen.

Of course, it was sometimes true that purchases on the 'never never' could lead to domestic over-commitment, but this was usually because domestic assests had relatively short lives. This was unlikely to occur with

* Walsh, H.G. and Williams, A. 1969, Current Issues in Cost-benefit Analysis (Centre for Administrative Studies occasional paper 11). HMSO, London.

long-lived assets. It was also noticeable that 'never never' households rarely appeared to be run down!

He could not easily concur that water authorities which borrowed money, especially at less than negative real cost, 'must sooner or later inhibit their capital works' whilst those paying directly from revenue escaped this fate. On the contrary, ever-increasing depreciation provisions could conceivably cause arrival at any inhibition much more quickly, since it would finance only a fraction of the work that would be possible on borrowed money for the same increment to charges. Water authorities borrowing at negative real interest rates and raising charges only in line with inflation would even make surpluses.

At a time when Sandilands replacement cost accounting was rejected by the accountancy profession and bankers questioned its fundamentals, when modest Hyde guideline adjustments to historical accounts might be relegated to footnotes, when inflation was still high and above interest rates, a move by the water industry to higher depreciation seemed singularly inappropriate. He believed that high charges to meet increased depreciation provisions, especially when they were assessed theoretically, would not serve the public well for the foreseeable financial future.

He had not seen any hard evidence that the water services were in worse shape now than 30 years ago. A great weight of public complaint had not been raised and yet consumers were surely less tolerant of discomfort now than then. As one who believed the industry was in better shape, he did not see any merit in an increasingly ageing population feather-bedding future generations by excessive cash purchases of long-lived assets. Knowing that he could expect nothing of posterity, he hoped at present for a little compassion from the author.

MR. R.N. BALMER (Severn-Trent Water Authority) said that he disagreed with two of the author's conclusions. Firstly, as two later papers pointed out, financial appraisal of individual schemes would provide contradictory preferences to economic appraisal of these schemes, and financial appraisal must be seen as unnecessary, except in testing the effect on charges of the one-off, large scheme.

Secondly, the author's objectives in respect of 40-60 per cent self-financing, a 2½ per cent levy on assets, and charging on the basis of marginal cost appeared to be in conflict. The proposals to calculate depreciation on the basis of the replacement cost of assets consumed (CCA) would provide finance equivalent to something like 1-2 per cent, in values of current capacity and assuming the average life of an asset to be 100-50 years. New demand was running at about 1-1½ per cent per annum of current capacity and CCA alone should therefore provide the 40-60 per cent self-financing required.

The 2½ per cent levy on asset value, however, would provide finance equivalent to a further 1½-1.5 or 1.6 per cent of current capacity, depending on whether assets were, on average, half-way or one-third of the way through their useful life. Thus, CCA plus the 2½ per cent levy seemed likely to provide an excess over annual capital requirements. Who was to receive the excess?

While it might be theoretically proper to charge for the marginal unit

at the marginal cost, in practice it was administratively difficult. As Mr. Rouse had explained (discussion in paper no. 5, p.5 14) marginal costs varied according to the district chosen. If, for simplicity, it was assumed that new capacity was provided at ten-year intervals, 10 per cent of an authority's area should be subject to long run marginal costs and 90 per cent to short run marginal costs each year. In economic terms, it was just as wasteful to apply the highest local long run marginal costs everywhere, i.e. even where surplus capacity existed, as to change average costs throughout; and in practice, marginal costing was incompatible with equalization over large areas. A 2½ per cent levy might produce a regional marginal cost, but it should be clear that this had no economic value whatsoever.

MR. P.T. McINTOSH (Department of the Environment) said that the use of current cost accounting with realistic depreciation on the current value of assets would lead to an improved understanding of the level of resources being used by the industry. If the current cost depreciation provision was expressed as part of the actual or implied price of services, then a more direct response from consumers, or the authority acting as proxy for the groups who were not directly charged according to the service taken, could effect demand or the provision of services.

However, the UK water industry was, to a large extent, a monopoly. Much of its revenue was presently gained from rate-based charges and there was thought to be little elasticity of demand to costs or prices generally. The industry's decisions were mostly based on views of future demand growth and standards of service to be provided; these were often more relevant than the consumers' direct response to charges. Thus, better costing was itself an important guide to the management and the planning of investment, operations, choice of priorities, and financing.

Author's Reply to the Discussion

MR. E.J. GILLILAND thanked Mr. Reed for his kind comments on the paper and for his support for some of the views expressed. In referring to Section 30 of the 1973 Act, he agreed with Mr. Reed that one of the basic problems which this section altered was that water services could no longer operate on a public health basis. The basis of charge was as Mr. Reed had said, now the cost of providing the services. One of the biggest problems here would be to sort out the question as to who should pay for surface water drainage, and on what basis they should pay.

Mr. Reed's final question, namely, what were the author's views on the steps necessary to ensure that the industry remained credible in the eyes of the public, was very apposite. The author said that there were three.

Firstly, the charging policies to be introduced by 1981 would not only be simple and acceptable, but hopefully of a fairly similar pattern throughout the country. To have ten different charging policies for services all of which might be different from the present one, was going to raise a number of questions on credibility in the eyes of the public. The second step was to ensure that financial policies were realistic. He had suggested the ways in which these could be achieved in the paper, but reiterated that there must be a move away from the basis of charging upon historic costs, particularly if increases in charges each year above the rate of inflation were to be avoided. The third step, which was really an extension of the previous one, was to ensure that all the problems regarding

the rising cost of replacement of assets could be adequately financed in the future.

On the points raised by Mr. Cole, he believed that when using the phrase "Economic appraisal", it should include both cost-benefit analysis and cost-effective studies. Cost-benefit analysis ought, in the main, to be applied where the income being raised was derived from a tax: whereas cost-effective studies were more suitable for those parts of the services where there was charging on the basis of services provided, or facilities made available. However as Mr. P.R. Herrington had suggested in his paper (p.6 1) the need to develop better methods of project appraisal should not be overlooked.

He was sorry to hear that Mr. Watson had not been convinced by his arguments and would want to continue borrowing for all capital investment. He himself was not advocating that the water industry should 'pay cash out of income rather than borrow'. In brief, what he was advocating was that the depreciation charged in accounts should reflect the current economic cost and the use of the assets concerned. To the extent that the money so raised was in excess of debt redemption, this excess could be used for self-financing.

In *Paying for Water*, the point was made that if charges were levied on this basis, this would lead on average to about 50 per cent of capital investment being self-financed. His point that purchasing on the 'never-never' could lead to domestic over-commitment was unlikely to occur within the water industry where the assets were of longer life, was just not true. There was evidence already that those authorities whose proportion of total expenditure on depreciation and interest was as high as 60 per cent were already feeling that they had been over committed in the past. In consequence, there was evidence to rebut a further point which he made that future capital expenditure had been inhibited by the apparent burden of previous investment. He was also sorry that Mr. Watson used the phrase 'an increasingly ageing population feather-bedding future generations' because he believed the exact opposite of what was happening and would continue to happen so long as charges were based on historic costs. The phrase "intergenerational inequity" was one much loved by economists: it was happening now. The present generation of consumers were deriving the benefit of assets provided by their forefathers and they were storing up problems for future generations when it came to replacing the existing assets. Mr. Watson's position at the CWPU should help him to look more kindly to posterity than some others.

Mr. Balmer said that he disagreed with a number of points and with two of the conclusions. The question as to whether financial appraisal would provide contradictory preference to economic appraisal was a matter of opinion and time and space did not permit him to develop arguments for the use of all of these techniques and not just the one Mr. Balmer seemed to favour.

Mr. Balmer had commented that the suggestion of 40/60 per cent of self-financing ratio and a 2½ per cent levy on assets appeared to be conflicting. As he said in reply to Mr. Watson, if depreciation was charged on a current costs basis, this should lead on average throughout the water industry, to an average self-financing ratio of about 50 per cent. It might well be that in some years, and in some authorities, this ratio might be as low as 10 per cent and sometimes as high as 90 or 100 per cent.

He did not advocate a "levy" of 2½ per cent on the value of assets. What he was proposing was that a return of 2½ per cent per annum on the basis of the current value of assets should be met. From this return, water authorities would, of course, have to meet interest on the loans they raised and only the balances of this charge would be used for self-financing. If, as Mr. Balmer seemed to suggest, this led to excess of income over annual capital requirements, the next step would be to repay existing loans. However, he himself doubted that water authorities would ever be, in the foreseeable future, in the situation where after having repaid all their debt they would be able to meet not only all their capital requirements but also to make further surpluses.

On the question of charging on the basis of marginal costs, he did not think it was as administratively difficult as Mr. Balmer suggested. Perhaps when Mr. Balmer had had the benefit of hearing Professor Hanke's presentation (p.5 13), he might be more convinced that the right basis of charge ought to be as close to marginal costs as could possibly be achieved at the present.

Turning to the final speaker, Mr. McIntosh, he found that he was in almost complete agreement with what he had said. It was because of the need to get improved understanding of the level of resources being used by the industry that he himself was advocating more realistic financial policies. However, it was not just better costings that were needed to help in improved management and planning investments and choices of priorities, but further understanding as to how consumers responded to changes in charges. He also agreed with Mr. McIntosh's comment that perhaps there was too much excitement about who paid rather than about the level of what should be paid.

3. SCIENTIFIC PRIORITIES AND PROBLEMS

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The main priorities and problems in water management as seen from the scientific viewpoint are outlined. These relate essentially to quality needs in the services of water resources management, public water supply and sewage disposal. Operational needs, to which overall priorities are assigned, are discussed and a brief outline is given of current changes, and need for further changes, in administrative and policy matters.

INTRODUCTION

Taking the purist scientific viewpoint of the water industry, parts of the current general policy of the industry appear illogical. This does not mean that practically we are all doing the wrong things. Indeed by and large the vast majority of people are being given the services they demand at reasonable cost. Nevertheless, fair success at the moment is no guarantee of future continuing success and accordingly, in formulating future policy, we must have regard to those present illogicalities which have, or are likely to have, real impact on water services. As far as possible we must seek to correct these as and when we can.

Where this process involves breaking the fetters, or discarding the fetishes, of the past, the juvenile, reorganised water industry is making significant steps forward in terms of expressed policy if not yet in practical application of that policy. There is much more to be done in this direction, and many important policy issues are in fact being neglected for various reasons. One obvious reason is that everything cannot be done at once. A second is that in respect of some issues, insufficient information is available to permit progressive examination of the problems involved and possible solutions. A third reason is that the urgency attached to some questions is far less insistent than that arising from the pressures of financial problems, and from such matters as the popular concern with the minutiae of water supply quality or the task of injecting practical realities into the draft Directives originating from ethereal Brussels. This situation is not peculiar to, but is certainly strongly evident in, the

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scientific aspects of water management.

Scientific consideration in the Water industry is generally construed as embracing the natural sciences, and more particularly chemistry and the life sciences. Generally but not exclusively these sciences are applied in terms of process and product control, be these processes and products contrived by man or environmental.

In this paper, some of the priorities and problems in this applied science will be considered in the context of current practice and the likely shape of future requirements and policy.

WATER RESOURCES

The scientific aspects of water resources management considered here relate essentially to the control of the quality of water resources so that public demands, often competing, for use or enjoyment of those resources can be met. The basic objective of this control is to achieve the maximum satisfaction of these demands at minimum cost to the public. Overall demands for the use of water resources for water supply, wastewater disposal and land drainage currently depreciate the environmental functions of surface waters in providing fisheries, recreation and amenity. Accordingly a major problem is to decide how far the environmental functions of surface waters should be protected or restored, bearing in mind that the costs of such action will have to be met almost wholly by users of public supply and sewerage and sewage disposal services.

However, where a river is currently, or is intended to be, drawn on for public supply downstream of developed areas, the need to protect the general quality of the abstracted water should also provide reasonable protection or restoration of the water quality needs of environmental functions upstream. Yet this partial resolution of the environmental problem is attended by a different major problem - that of ensuring that the quality of the water supplied contains no residuals of the pollution originating from the upstream developed area likely to be harmful to the health of consumers. The priorities which need to be applied in tackling these two scientific problems in water resources management will now be considered in turn.

Environmental Priorities

There are three fundamental considerations to be taken into account by the water industry in formulating environmental priorities. First, it is virtually axiomatic that for many years there will not be sufficient finance available to achieve the protection and restoration of the environmental functions of surface waters that may be considered desirable or demanded as necessary. Second, and consequentially, the environmental priorities must conform to the principle that whatever money is available, expenditure of it must be directed towards maximizing the resulting environmental benefit. Third, it is a fact that the only true measure of environmental conditions is an ecological one, embracing physical, chemical, and biological factors.

In terms of the environmental functions of surface waters, there are four clearly defined quality states of importance. These are, in descending quality:

1. A state of outstanding natural beauty, where the outstanding characteristic is judged not only on the national scale, but also on the regional scale.

2. A state of supporting a diversity of fish life appropriate to the physical characteristics of the river channel or lake bed.

3. A state of being substantially fishless.

4. A state of causing public nuisance.

These quality states will now be used to determine environmental priorities in broad terms.

For obvious reasons the first priority should be afforded to the elimination of public nuisance from all waters. Fortunately there cannot be many, if any, waters currently causing real public nuisance in England and Wales.

The second priority should be to ensure protection of the surface waters of outstanding natural beauty. This is required to stop the steady loss of those remaining very important assets in upland, downland and lowland areas where needs for the conservation of both scenic amenity and diverse species of aquatic life are predominant. These waters also support the bulk of the inland food fisheries, and very good coarse fisheries to provide angling recreation of the highest quality. These waters are not generally subjected to serious threat of quality depreciation by wastewater discharges. They have so far been unspoiled because development is not intensive, and they are certain to be protected from large-scale development by the planning authorities. They could support all local needs for water supply and waste disposal. However, they are seriously threatened by increasing water abstraction for export to developed areas.

This seriously diminishes the base flows of the streams to change drastically their character and to reduce markedly their capacity to cope with local sewage effluent discharges, nutrient additions from land run-off, and the effects of land drainage operations.

Typical examples of the results of this process are common in the chalk and limestone streams of south-east England. Here water abstractions from the aquifers authorised in the past have grossly inhibited the natural environmental functions of many streams, and the same result will be produced in other streams unless changes are made in policy. Large new groundwater abstractions are still being authorised for export on the basis that the effect of each individual new abstraction will not be significant, when it is certain that in due course the summation of such individual effects will be very damaging.

Such schemes as compensation-water pumping from aquifers and the switching of abstractions between boreholes to avoid the drying-out of streams, cover up the extreme consequences of abstraction but do not prevent gross changes in the overall stream quality occurring. The water industry should adopt the general policy that water abstraction from chalk stream aquifers should be reserved to meet local needs, and that new abstractions for export elsewhere should be met by abstraction from well downstream in less critical reaches. In other areas action with the same intent may well be necessary, depending on circumstances. In respect of all streams of outstanding natural beauty, strict control of schemes of water transfer, particularly those making changes in the chemical quality of water, and of permanent land drainage works, will be necessary to minimise the environmental consequences of these schemes.

The third priority should be to ensure that no stream supporting a fishery of a diversity appropriate to the physical characteristics of the stream channel should be allowed to deteriorate into the substantially fishless state. The main reason for this is that such deteriorations arise mainly from the polluting effects of wastewater discharges which destroy not only fish but also a whole range of species of aquatic biota. In broad environmental terms, a stream supporting a reasonable fishery will have a reasonably diverse ecosystem at the minimum level that can be regarded as ecologically acceptable. It is important that deterioration below this limit should not be allowed to occur. At this level of ecological acceptability a stream will support all normal recreational activities, as well as being fit for abstraction for public supply after appropriate treatment.

It follows that the fourth priority should be to improve fishless streams to the state where they support appropriate fish life. Indeed there is little point in improving any stream which is polluted and fishless, but not in a state causing public nuisance, to any quality level less than that of being able to support fish life. There is little environmental or recreational advantage in doing less. That the maintenance of fisheries in streams should be afforded a higher priority than improvement of a fishless stream might be queried. The answer is that for years our national approach to pollution control has been to prevent deterioration first and seek improvement as and when possible. There is no general necessity to change this approach. Furthermore, it is generally less painful for the public and certainly for anglers, to be denied an advantage they have not hitherto enjoyed than it is for them to witness the loss of an existing asset. It is also relevant to note that some urban streams which are currently fishless might not be transformed into a fishery simply by improving the quality of wastewater discharges. It may be necessary also to provide lakes in the stream to eliminate the polluting effects of urban run-off, including that from storm sewage discharges.

The question might arise as to what priority should be afforded to improving the quality of a stream, which is a reasonable fishery, to a higher level nearer that expected of a stream of outstanding natural beauty. The answer is that

such action is unlikely to be worthwhile on environmental grounds alone, but there may be other grounds for this action, such as improvement of raw water quality for potable abstraction.

In the case of tidal waters somewhat different considerations apply. Here the first priority should be that of pollution control to avoid public nuisance, including the fouling of beaches, and to prevent food fish becoming contaminated and harmful to the health of consumers. The second priority should be the protection or restoration of food fish resources, including the passage of migratory fish through estuaries which has implications both to pollution control and to the maintenance of minimum freshwater discharges. A similar priority should be afforded to special conservation of areas of outstanding natural beauty and sites supporting rare aquatic species and important species of water birds. The third priority should be to protect the pathogenic quality of the water in areas supporting aquatic-contact recreation, e.g. bathing beaches.

Control of Effluent Discharges

Good progress is being made by the water industry in rationalising the formulation of consent conditions applicable to discharges of sewage and trade effluent to surface waters. The new approach has been publicised in the National Water Council's Consultation Paper, and in the main public reaction to the changes proposed has been favourable. Essentially, the change involves the specification of quality objectives for freshwater streams, derived from a new classification of stream water quality, which is related to stream uses and employs mainly chemical parameters of quality. Consent conditions (standards) for new discharges and for applications to existing discharges, through a review process, will be calculated to provide that the quality objectives for the receiving stream will be nominally met for 95 per cent of sampling occasions. These quality objectives will be stated in terms of current objectives which are being achieved, and should be maintained if reasonable capital investment programmes are possible, and in terms of future objectives which may be the same as at present, or upgradings of these, depending respectively on whether present stream quality is adequate or in need of improvement.

The primary merit of this new approach is that it will permit capital investment in effluent treatment works, public or private, to be directed to where it is most needed in pollution control. It will also set a new base-line against which the water industry's future performance in pollution control can be measured, and hopefully shift professional and public concern in pollution control away from effluent quality, which in isolation means little in environmental terms, to stream quality which is an environmental fact.

The problem of formulating, and securing, majority public support for this new approach has been dealt with by the National Water Council. The problem of applying the new approach is now being tackled. The problem of deciding what priorities

should be applied to expenditure on pollution control is also being taken on and the comments earlier in this paper will hopefully assist in this. The problem of deciding at what rate river improvements, through better effluent treatment, should take place, bearing in mind the needs and demands for investment in other water services, and national competition for shares in the quantum of public expenditure available year by year, is in the main a political problem. There is of course, much illogicality in the popular view of water pollution. Very little pollution in England and Wales is now the disaster that people have been persuaded or even frightened into believing by television and the press. If it is, why is it now so difficult, compared to the position 20 years ago, to find visual evidence of gross pollution? - there are many figures available showing the BOD of many effluents and waters to be high, but to take these figures alone as proof that all these waters are foul is to say the least, stretching the truth. These comments are not intended to imply that there is not massive effort and expenditure yet to be applied in maintaining and improving effluent and stream quality, but simply to point out that the real situation is by no means as bad as it is painted. If the rate of progress achieved on the average over the last 20 years is maintained, then nearly all streams should be substantially clean before the turn of the century. Will this be adequate progress bearing in mind the longer term national economic outlook?. Adequate or not the total bill for this progress, and for holding the position once the objectives are achieved, will be massive.

In the control of the quality of effluents discharged to streams which are subjected to subsequent potable supply abstraction, the limitations of conventional sewage treatment need very much to be borne in mind. While clearly high levels of degradable organic pollution in any water supply stream cannot be accepted for a number of reasons, waterworks treatment processes are, or should be effective in dealing with residual degradable organic pollution abstracted from streams. These processes are however much less effective in dealing with non-degradable pollution in abstracted waters.

Conventional sewage treatment is specifically designed to remove, by settlement and by bio-oxidation, most of the degradable organic matter in the inflowing crude sewage. Not by design, but because of normal physical and chemical phenomena, solids settlement at sewage works removes much of the toxic metals and fair proportions of some other unwanted substances present in sewage, to the benefit of the receiving streams and the detriment of water authority sludge disposal options. Bio-oxidation processes at sewage works also degrade carbonaceous and nitrogenous substances much faster than natural processes would in streams. That is about the sum-total of current sewage treatment capabilities, and a host of substances, many of unknown nature and properties, in low concentration, many derived from industrial processes, and some from domestic sources and human metabolism, pass through sewage treatment substantially unchanged. This is the reality which presents a considerable water management problem in relation to abstractions for public supply from lowland streams.

Consequently a high priority needs to be maintained in research and development on establishing the nature and method of assay of these substances and on establishing the public health implications of the possible presence of these substances in water supply. There is also a high priority need to carry out the catchment quality control investigations already initiated in Thames Water, whereby attempts are made to establish exactly what trace chemicals (as distinct from the substances normally subject to trade effluent control) industry is discharging to streams, directly or via sewers and sewage works. Obviously where present normal trade effluent control is, for whatever reason, inadequate a top priority should be given to rectification of this.

Consideration is currently being given to the advantages and disadvantages of development of a system of charging for discharges of sewage and trade effluent to rivers. It is inappropriate to consider here the economic arguments of this matter other than to observe that under appropriate circumstances a system of charging may be a very useful adjunct to the present consent system of controlling effluent quality, particularly in bringing about improvements in river quality. However, in considering the subject, regard must be properly paid to the practicalities of river management. The element of economic choice in the options of whether a trade effluent discharge should pass to river or to a sewer, assuming both actions are physically possible, and of whether increased costs should be incurred in effluent purification before discharge to river to reduce charges for effluent discharge or vice-versa, would in many cases be constrained by technical requirements. For example, in planning a river quality improvement scheme one needs to be sure that the desired level of quality will be achieved so that the desired new river uses can be attained and maintained. In this, the giving of choice to an effluent discharger either to improve his effluent or pay the costs, through a charging scheme, for discharging the unimproved effluent, introduces a considerable planning uncertainty which is likely to be unacceptable. The notion that an industrial effluent discharger, physically able to choose between discharging to a sewer or to river, can make his choice wholly to suit his economics, becomes considerably circumscribed when regard is paid to the difference between the dilution available to discharges which pass to rivers via sewers and sewage works and that available to direct discharges to rivers, and when account is taken of the benefits of treatment at sewage works which are not paid for in current trade effluent charging systems.

A trade effluent containing say 10 mg/l cyanide, or 10 mg/l of some toxic metals may be quite acceptable into a large sewer and sewage works, at zero charge in respect of these contaminations. The same trade effluent would have to be treated by the industrial concern involved for removal of much of these contaminants before discharge direct to a river. Certainly, accidental discharges of highly toxic wastes from industrial premises to sewers draining to large sewage works are usually diluted into insignificance, or otherwise are controllable on arrival at sewage works. The same accidental discharges direct to rivers would normally cause a great deal

of trouble in those rivers. However the existence of these realities, and of other administrative realities which militate against general introduction of charging schemes for effluent discharges, do not imply that the possibilities of introducing such schemes should be abandoned without further examination. But such work can hardly be afforded a high priority.

Operation of the administrative rules of current control of trade effluent discharges to sewers also needs review to ensure that these are being sensibly applied. Following the 1976 drought, many industrial concerns have generally reviewed their water usage and their scope for water re-cycling. In some cases water demands have been markedly reduced, with the result that trade effluent volumes have been reduced while effluent strengths have increased. This is sound, and much needed, water conservation which any right-thinking water authority should generally support. Concern with loss of income from reducing industrial water demand should not be allowed to cloud the essential need for water conservation; there may be many cases where loss of water supply income could be largely offset by increased income from treating stronger trade effluents at sewage works, unless the receiving sewers and sewage works are just incapable of coping with the changing situation. Unless these latter circumstances genuinely apply, rigid adherence to general trade effluent control rules, for example, that the suspended solids and BOD limits applicable to trade effluents should be around those of domestic sewage, regardless of what concentrations sewers can carry safely and sewage works can deal with, is unwarranted and unproductive.

Open-mindedness on other aspects of pollution control, particularly when this applies to a water authority's own works and discharges, should be the order of the day. It would be no bad thing at all that every water authority should seriously review its internal water quality control arrangements and ensure that any changes necessary are made to demonstrate to the public that everything is above-board, and that their pollution control is strict and impartial both in theory and practice. In this respect, the publication of masses of water and effluent quality information is not enough. The aim must be to show clearly that effective organizational arrangements have been made and are operating to ensure that the authority's own activities in effluent purification and disposal are subject to exactly the same scrutiny and public reporting, with the same diligence, as are applied in regulation of private activities. It is only too easy for slipshod control to develop, even when all the proper basic arrangements exist, and failure of only one authority either to make the proper arrangements or to keep these working properly, could bring the whole water industry into disrepute, and worse.

Control of Groundwater Pollution

The outlook of the water industry on this subject needs objective review. Present thinking is largely the same as in the past and needs bringing up to date. For example by any yardstick, the cesspool is, at its best, one of the less

desirable arrangements for sewage disposal. Yet many authorities insist on provision of these, instead of the much more suitable septic tank/soakaway systems, if they lie on permeable stratum within one kilometre of a water supply borehole. Why not 1.1 Km or 0.9 Km? and how many truly watertight cesspools exist? Decisions on these matters should be made by hydro-geologists in the light of the circumstances of each case and the kilometre rule and similar arbitrary yardsticks banished.

The main need for the availability of hydro-geological knowledge and skill does not of course arise from the cesspool/ septic tank question. It arises in connection with proposals, and needs, for refuse disposal by tipping, which subject seems to bring out the utmost conservatism, not to be confused with conservationism, within the water industry. The contribution of the Groundwater Pollution Unit of the Institute of Geological Sciences to the understanding of underground purification processes is a valuable piece of work, and certainly should not be regarded as a factor leading to opening of the floodgates to wholesale new groundwater pollution. Demonstration by scientific experiment and observations of the redundancy of long-held cherished principles,based on protective assumptions,is an advance not a retrogression. It may have uncomfortable results for those who prefer to make anti-pollution decisions by rule-of-thumb rather than by rule-of-informed-judgement. It also may encourage those who wish to dispose of waste as easily and cheaply as possible that nothing can now stand in their way. Such things are often the consequence of new knowledge.

Of course, it is of great importance that groundwater resources should not be fouled with contaminants from tipping, and it is the clear duty of water authorities to prevent this. It is the way in which this duty is currently discharged which needs review, and urgently.

PUBLIC WATER SUPPLY

By and large the public supplysystems of water authorities, in the quality context, are in pretty good shape when compared to the shortcomings which exist in some areas regarding sewerage and sewage disposal and river quality. Nevertheless, there are problems arising which need to be tackled seriously, some with greater urgency than others.

Protection of Sources

Over recent years there has been a marked change in outlook regarding the protection of raw-water storage reservoirs - from prevention of contamination by the organisms responsible for waterborne disease transmission to prevention of chemical contamination. The pressure for water-space recreation has been one cause of this change, while the increasing use and transport of chemicals generally and the proliferation of motorways are other causes.

Raw-water reservoirs are now increasingly being opened to public use, and the waters from such reservoirs are concurrently being given comprehensive treatment before use, but this gives no reason at all for relaxation of vigilance. The undoubted tendency will be for slackness in control of reservoir use to creep in and too much reliance being placed on treatment processes, none of which are infallible. A stand against this must be made now otherwise very serious troubles will develop eventually. Chemical contamination of storage reservoirs resulting from a road accident could have most serious and long-term consequences in the reservoirs and yet this cannot be completely guarded against. Securing the maximum practicable protection from such accidents, and complete intolerance of any dumping of refuse in reservoir catchments, must be regarded as a high priority pollution control activity.

On lowland rivers used as public supply sources, again it is the accidental pollution which presents the major problem, assuming that the necessary river pollution control needs outlined earlier are put into proper effect. Intakes abstracting water for immediate use from developed river catchments should be provided with bankside storage both to protect the consumer and to provide a reserve of water for supply in the event of intake closure. Where the source river has a high base-flow in relation to the volume of the abstraction, drains a catchment area with little urban and industrial development, and there are no trunk roads draining to the river within one day's flow-time of the intake, then bankside storage could reasonably be omitted provided an alternative source of supply can, if necessary, be drawn on immediately. The priorities to be attached to the provision of these safeguards is a matter for local judgement. Where difficulties have occurred in the past to the extent that public supplies have been interrupted or have been in danger of interruption, top priority should be afforded at least to ensuring the availability of adequate alternative supplies in the event of further pollution occurring.

Some comment has already been made on the subject of groundwater pollution control. The risks of serious pollution arising from disposals of sewage effluent into the ground or from properly controlled tipping are minor when compared to the risks of serious oil pollution of borehole and well sources of supply. Major spillages from oil depots and underground oil service pipes at industrial premises located on permeable stratum have caused and will continue to cause very serious groundwater pollution problems. Prevention of all these mishaps from time to time in built-up areas seems impossible, and priority for action must be reserved to vigorously combating and eliminating the consequences of mishaps as and when these arise.

Water Treatment

The most vital aspect of public health protection in water treatment is disinfection, and the highest priority must be afforded to the provision and maintenance of this. Everybody knows this but everybody does not act on this principle. Furthermore, it must be borne in mind that disinfection

processes are only fully effective in treating a well-clarified water, and that rapid disinfection of viruses by chlorination requires the presence of free chlorine. Thus the most perfect systems of chlorination become less than perfect if the water to be chlorinated is badly filtered or contains ammonia in excess of 1 mg/l.

Chlorination has of course been questioned as a suitable process when applied to waters containing hydrocarbon and similar organic residues because of production of chlorinated hydrocarbons. To replace chlorination by ozonisation or other disinfection processes for such a reason seems to be bad water supply practice - a palliative rather than a preventive process. What is needed is removal of the unwanted organic compounds from the water before chlorination.

A problem in water treatment which occurs almost every summer is that of algal-clogging, or of algal breakthrough, in rapid sand filtration following normal coagulation treatment. While the use of flotation processes or laminar sedimentation may ease this problem, it seems that for so long as water sources, including impoundments, produce algal blooms, so will coagulation/rapid filtration processes run into problems from time to time. There can now be little doubt that the most reliable water-clarification treatment process is slow sand filtration. Further it has been demonstrated that this process, coupled with reservoir mixing to prevent stratification and depth-localised algal blooms and to give a valuable measure of biological control of phytoplankton concentration, together with roughing filtration before slow-sand treatment, produces satisfactory results even under the drought circumstances of 1976.

The problems of nitrates in public supplies have been characteristic of the successive dry years experienced between 1971 and 1976. While such problems can be expected to be less severe and more localised in years of normal rainfall, the trend is certainly for matters to worsen as agricultural activity intensifies and as sewage effluent volumes increase. There is no urgent priority to tackle the nitrate problem generally by provision of denitrification processes at the relevant waterworks as fast as this can be done. Where difficult problems exist now, of themselves they demand priority for remedial action. We should be able to predict the onset of new difficult nitrate problems, and take action by means of special water (and sewage effluent) treatment for nitrate removal as and when necessary to forestall trouble.

Distribution

The complex relationships between the effects of treated water quality on water mains problems, and of the effects of water mains on tap-water quality problems are little understood. It is however well-established that the distribution of supplies rich in organic content results usually in mains infestation problems and taste and odour problems in tap waters. The continual distribution of water relatively rich in aluminium derived from coagulation problems is also likely to cause

problems in due course. On the other hand, it is also fairly well established as to what aspects of water quality cause corrosion of mains and plumbing, and cause the take up of lead from lead mains and plumbing. In general the lead in tap water problem is the most urgent one. Certainly where first-draw tap waters contain lead in excess of 0.3 mg/l a high priority for the taking of remedial action is needed. Since it seems unlikely, in the immediate future, that waters aggressive to lead piping can be rendered non-aggressive by adjustments to water treatment processes - e.g. the hardening of treated waters before distribution - without running the risk of creating new problems in distribution, the removal of lead mains and lead piping in problem areas seems to be the only practicable and satisfactory solution. The costs of this solution are likely to be so high that corrective action will not be rapid. Further research into plumbosolvency and its correction may in due course point out effective ways of securing faster and cheaper progress in solving this problem - at least to the level where first-draw tapwaters do not often exceed 0.1 mg/l, which will go a long way towards ensuring that supplies drawn at other times will be well within the WHO limit of 0.1 mg/l.

SEWAGE DISPOSAL

The immediate problems in sewage disposal from the scientific viewpoint can be summarised into two categories. The first is that of improving sewerage and sewage disposal systems to yield the improvements in river quality in the locations and on the timescale deemed appropriate. Comment on the priorities to be pursued in tackling this problem has already been made under the heading of "Water Resources". The second is that of coping with the increasing difficulty of disposing of sewage sludge as pressures for protecting the land and estuarine environments builds up.

We are already facing new constraints on sludge disposal to land following publication, jointly by the Department of the Environment and the National Water Council, of the "Report of the Working Party on the Disposal of Sewage Sludge to Land". This report recommends, inter alia, that sludge disposal to land should be in accordance with the Guidelines contained in Chapter 6.

While there are still very considerable reservations within the water industry on the quality of the scientific evidence on which the Guidelines are based, attention has to be directed to the way in which water authorities are to proceed in endeavouring to conform with the new guidance.

The first priority must be to achieve conformity with those guidelines of primary concern to public health. In particular, conformity with the guidelines on limitations of the cadmium additions to land from sewage sludge, to prevent crop contamination, must be given the most urgent attention, for obvious reasons. All water authorities should be able to achieve this conformity quickly, notwithstanding that to do so will involve additional expenditure of several millions of pounds per year. While there is little evidence available to indicate

that the disposal of untreated sludge to land actually creates any real public health hazard, there is a degree of theoretical risk involved, and there is no doubt that real problems in relation to animal health arise. Accordingly water authorities should take steps to conform with this guideline as soon as practically possible. Regarding prevention of phytotoxicity due to toxic metal build-up in land treated with sewage sludge, in many uses the limitations on cadmium additions to land will also take care of the phytotoxicity question. Where such overriding limitation will not arise, then achievement of conformity with the guidelines regarding phytotoxicity will rank third in priority, not only because of the lesser relative importance of this question, but also because it is on this question that the scientific basis of the guidelines is the least convincing.

The disposal of sewage sludge to sea, especially from the big sewage works serving large cities near the coast, is the cheapest method of disposal. Accordingly, demand for increased use of this method is rising, while the Ministry of Agriculture, Fisheries and Food can be expected to place increasingly stringent limitations on the toxic metal and non-degradable organic chemical content of dumped sludges. Subject to such limitations as may be deemed necessary, in particular on mercury, cadmium, and pesticide residuals, there is no cogent reason why disposal of sewage sludge to sea, at appropriate locations, should not continue and expand.

One frequently hears the argument that dumping of sludge at sea is a waste of resources in that sludge contains reusable materials, especially the land-fertiliser chemicals. This is true, but at the present time neither the economics of recycling of these materials, nor our technology of doing so, are good enough to support the argument.

The treatment and disposal of sludge accounts for a substantial proportion of sewage treatment costs. In Thames Water this proportion is one third. Elsewhere a higher proportion probably applies. It follows that a high priority should be given to research and development directed at reducing these costs. Having regard to the intrinsic properties of sewage sludge which make it costly to dewater, the best hope for the future seems to lie in the development of methods for profitable recovery of valuable materials for recycling, rather than in seeking improved methods of dewatering sludges as an aim in itself. The most promising prospects of recovery of materials seems to be in improving methane gas production, recovery of ammonia and phosphate from digester liquors, and the recovery of fat and proteins (not for human consumption) from sewage sludges. Pursuit of these aims will no doubt lead to improved methods of sludge dewatering being developed. In sewage treatment itself there are at present no very urgent needs for the development of new processes, although obviously any cost-reducing advances in treatment technology will be welcomed. However, there may well be especially rewarding scope in seeking the utilisation of oxygen gas in the treatment of particularly strong sewage (and trade wastes), in boosting the performance of overloaded works, and in maintaining minimum levels of dissolved oxygen in estuaries as an alternative to treating effluents

to high standards of organic quality.

There is one particular aspect of sewerage and sewage disposal where some rethinking of current technical policy is likely to be worthwhile. This is in the provision of rural sewerage and sewage disposal schemes. These schemes have hitherto been modelled on the pattern appropriate to urban areas. The aim has been to centralise the sewerage systems of villages into the nearest town system or to a new works serving several distant villages, to achieve an effective scale of conventional treatment and minimise labour costs at sewage works. It is questionable whether construction of such long lengths of mainly conveying sewers, leading to high-cost schemes and pressure for as many properties as possible to be connected to sewers whether necessary or not, can now be justified. Is it not time to consider the design of inexpensive rural schemes to meet rural circumstances instead of continuing to provide the countryside with costly and scaled-down replicas of urban schemes?

E.E.C. Requirements

We are currently plagued with a batch of draft E.E.C. directives aimed at developing common yardsticks of, and uniform progress in, maintenance and improvement of the quality of waters for beneficial use and environmental conservation. Few people welcome the additional burden or work involved in assessing and seeking sensible modifications of these drafts, but the major unsatisfactory character of these draft directives is that they are prepared from the top-down so to speak, by people with little if any practical knowledge of water management and its problems. Because of the supra-national status of the E.E.C. and the protocol thereof, the experience and knowledge of practitioners in the water industry throughout the E.E.C. is not brought into consultation until the drafts are promulgated, and then only into secondhand contact with the E.E.C. officials through central government staffs.

We have had draft directives on the quality of waters abstracted for drinking, on the quality of waters intended for drinking, on the quality of waters intended to support freshwater fish life, and shellfish, on quality of waters intended for bathing, on the discharge of pollutants to groundwaters, and on the control of polluting emissions of various kinds into waters. The illogicalities and impracticalities initially built into these directives would be laughable if the whole system of their production was not so perversely inverted as to arouse strong feelings of frustration. The only crumb of comfort is that probably the E.E.C., with all its faults, is less of a hardship to us than the Environmental Protection Agency is to water managers in the U.S.A.

Essentially, of course, the water industry in the U.K., and our Department of the Environment, are proceeding through a painful process of educating the E.E.C. staffs, and our continental counterparts, on the realities of water pollution control, at the end of which all will turn out reasonably well and hopefully we shall learn something in the process. This of

course is the kind of fate likely to befall any person or organisation, which has being doing a job, alone and unnoticed, for a long time, when the purpose of this job suddenly becomes fashionable and generally applicable.

CONCLUSION

There are, no doubt, as many variations of the scientific problems and priorities in water management as there are scientists prepared to give an opinion. Some readers will conclude that opinions are not good enough, and that all propositions for maintaining or improving water services should be subject to rigorous cost-benefit analysis. This would be a fair comment if the same people had any practical clues as to how benefits in matters of water quality could be quantified in terms of cash value.

Some of the matters referred to above can be subject to cost/benefit analysis, for example, whether it will be worthwhile to extract reusable materials from sewage sludge, and opinions expressed on these matters are derived from intial cost/benefit assessments.

In the span of this paper, it is not possible to refer to every problem in the scientific aspects of water management, or to cover the details of the more important matters. Of the various matters referred to, most relate to operational needs, some to research and development, and the remainder to the development of new attitudes in policy and administration.

In operational needs, the overall priorities to be allocated to the most important ones can be summarised as follows:-

1. Top priority should be afforded to providing and maintaining proper disinfection of public water supplies.

2. Second priority should be given to guarding against the ingress of toxic or otherwise obnoxious substances to public water supplies through pollution control procedures and provision of raw water storage at intakes abstracting from rivers subject to risk of gross accidental pollution.

3. Third priority should be given to elimination of contamination of drinking water from lead mains or pipes wherever such water, on first draw, contains regularly more than 0.3 mg/l.

4. Fourth priority should be applied to prevent contamination of food fish with toxic substances beyond the safe levels applicable to food.

5. Fifth priority should be given to the elimination or prevention of public nuisances arising from pollution of surface waters (and from sewage disposal).

6. Sixth priority should be afforded to ensuring that disposals of sewage sludge to land conform with guidelines relating to cadmium.

7. Seventh priority should be given to maintenance of the quality of rivers considered to possess outstanding natural beauty, essentially by strict control of abstractions and other proposals involving changes of river regime.

8. Eighth priority should be afforded to the protection or restoration of freshwater, migratory, and sea fish, and to special conservation of rare biota.

As regards the reference made to research and development and to policy and administrative matters, it is not feasible to allocate priorities to these. In summary, it can be noted that the research and development matters of particular importance from the scientific viewpoint relate to investigation of the trace chemical contamination of lowland river sources of public supply, of the possible water quality adjustment cures of plumbosolvency in distribution mains and household plumbing, and of the recovery of re-usable materials from sewage sludge. In administrative and policy matters particular regard should be paid to the need to limit abstractions from aquifers for export elsewhere, to the rate of progress to be made in general river clean-up, to supporting industrial water conservation and providing associated flexibility in acceptance of trade effluents, to reviewing the water authority attitudes to control of their own effluent discharges, to reviewing arrangements for groundwater pollution control, and to reconsidering the basic design of rural sewerage and sewage disposal schemes.

In total therefore, there is a great deal to be done, much of it making very heavy demands on financial and manpower resources and the remainder demanding radical changes in the thinking and outlook of personnel. What else could be expected in a radically reorganized industry some three and-a-half years into the job of managing the whole water cycle, including provision of the basic services on which modern society primarily depends?

DISCUSSION

Author's Introduction

MR. H. FISH, in his introduction, said that in the first sentence of the paper, he had said that *parts* of the current general policy of the water industry appeared to be illogical. Since writing the paper, he had changed his mind: the whole water industry was in a completely illogical situation. On the one hand, the industry was required by statute law to conserve water resources; to produce and distribute wholesome and adequate supplies of water; to maintain or restore the wholesomeness of inland and tidal waters; to provide for the disposal of sewage and trade effluents passed to sewers; to provide effective land drainage and flood control; to maintain, improve, and develop inland and migratory fisheries; to provide water recreation and amenity; and to have regard to the preservation of natural beauty and related matters.

On the other hand, to carry out these duties properly would involve massive expenditure on capital and revenue accounts, which expenditure the nation just could not afford now, or in the forseeable future. In this situation, it was crystal clear that the limited financial resources available

must be deployed in the first instance to meet the immediate and essential needs of water supply, waste water disposal, and flood control; which would leave little to be spared for carrying out the other, non-essential, albeit desirable, statutory duties of water management relating to improving the quality of "open air" life. This he called Fact 1 of current water management realities.

Furthermore, even if financial limitations were much less constraining than they were now, the true and effective discharge of all the industry's statutory duties would require that most of its resources, effort, and skill be directed to minimizing demands for water supply and minimizing the fouling of water in its use. The water industry was certainly not doing this, and there were practical limitations on the pursuit of this policy. Nevertheless, there was scope for progression in this direction. This was Fact 2 of current water management realities.

Taking Facts 1 and 2 together, it followed that the industry's justifiable spending priority, which was on the management of water resources, water supply, and waste water disposal, should embrace the principles, wherever practicable, of true water conservation; i.e. seeking the minimum demand on natural resources, the minimum fouling of water in use, and the maximum re-use of water. This would itself achieve a considerable measure of protection or improvement of the environment in terms of maintenance of natural river flows, river quality maintenance and improvement, protection of amenity and natural ecology etc. Furthermore, whatever finance was available to achieve additional maintenance and improvement of the environment, it should be applied where it would achieve the maximum benefits.

It was these principles which underlay most of the points he made in the paper, and on which he had a few additional comments to make.

On environmental priorities, he did not expect that his suggestion regarding protection of streams of outstanding natural beauty from the depredations of excessive water abstraction would be very popular within the water industry. Apart from the fact that this suggestion would raise the costs of relatively cheap sources of water, he stood to be accused of siding with the extremist environmentalists. He was not doing this. Not all environmentalists were extremist. The responsible ones were not always wrong in everything they said about water management. All he was saying was that he did not agree any more with the extremist water abstractor than he did with the extremist environmentalist. He certainly did know of streams, free of effluent discharges, which had been damaged by excessive water abstraction, just as much as if they had been loaded with effluent.

He had pointed out in the paper that the true measure of environmental conditions was an ecological one. In this context, it was increasingly unsatisfactory that water authorities generally knew so little about stream ecology. They knew quite a lot about stream biota, and they continued to strive at the not-so-worthwhile task of endeavouring to classify stream water quality wholly in terms of the invertebrate species; and the relative abundance of these species, in stream riffles. The biological effort of the water industry badly needed redirection into the ecological approach so that meaningful answers could be given to the questions of what effects changes in river regime and river quality were likely to cause in river environments and how these changes could be minimized. An essential precursor of this redirection of effort would be a new ecological research programme, as a general extension of the type of work initiated on chalk streams by the former Water Resources Board and the Thames Conservancy and now being continued by the Freshwater Biological Assoc-

iation under the sponsorship of the Central Water Planning Unit, the Thames Water Authority, and the Nature Conservancy Council. The water industry had a responsibility to underwrite, at least in part, such a research programme through the agency of the Water Research Centre, and it was high time that this responsibility was recognized and accepted.

Regarding the control of effluent discharges, as indicated in the paper, there was a need to concentrate attention on stream quality objectives, and to give figures of Biochemical Oxygen Demand of river quality less attention. It was stream quality which mattered in terms of both river use and environmental concern, and not effluent quality. To know the BOD of a river water was of little value unless it was related to the physical characteristics of the river. The dissolved oxygen concentrations, ammonia concentrations, and concentrations of toxic and non-degradable organic materials in solution were generally of much greater value as indicators of river water quality than BOD.

Readers of the paper would, no doubt, conclude that he was not at all enthusiastic about the possibilities of instituting charging schemes for effluent discharges direct to rivers. He was not opposed to the idea and its intentions, provided it would be used to supplement the exisiting consent procedures. His reservations were essentially that there were few reaches of rivers in the country where a system of charging for effluent discharges would give real benefits which would be anywhere near equal to the costs involved in developing and operating a charging system. Also, that the practical requirements of establishing and maintaining a high degree of pollution control were too complex to be consistent with a charging system which would necessarily have to be simple and thus insensitive to complex considerations of quality.

On the subject of the quality of public water supply, he had the same uneasy feeling as he did on the subject of water authority control of the authorities' own discharges that standards and vigilance in the application of standards would begin to slip unless a positive campaign to avoid this was put in hand throughout the industry. It was far more important that attention be given to these matters than to worrying unnecessarily about possible trace chemical pollution of water which was probably of no consequence. He was not referring to chemical pollution beyond the limits already specified by the World Health Organization and other expert bodies, but to the present unbalanced concern with chemical contaminations at exceedingly low levels which could now be demonstrated by the modern, highly sensitive, machinery of chemical analysis. Again, these views would not be very popular in some quarters, yet it was necessary to warn the industry that it must not fail to deal with real known dangers because it was too involved with grappling with possible dangers which had not yet been shown to be dangerous.

Regarding sewage disposal, he could not help being critical of the recently published *Guidelines for Disposal of Sewage Sludge to Land*. His view was that in this matter, the DoE, and the NWC in some degree, clearly demonstrated their capability of developing hot-heads and cold feet in situations where just the opposite was called for. While few people would wish to argue strongly that the suggested limits for additions to land of cadmium in sewage sludge were inappropriate, the same could not be said about the suggestions relating to limitations of other metals based on considerations of phytotoxicity. These were much too stringent, and were clearly based more on theory than practical reality.

By and large, the points he had made both in the paper and in these opening remarks resulted from a broad sweep over the scientific field of water management. In the interests of brevity, he had omitted to refer to large areas of detail, and he was sure that he would be corrected because he had been too

"cavalier" in his treatment of the subject.

The list of priorities he had given was what he endeavoured to work to, although he had not yet confirmed these priorities in cost-benefit terms, or in terms of a points system. It would be appreciated, no doubt, that of the first six priorities listed, five related to the protection of public health, and one to the elimination of public nuisance. Were cost-benefit or points-allocation systems necessary in this context? All these things needed attention and action without quibbling, and there was no choice but to raise the money to do this.

Finally, he commented on research and development. The industry was not doing enough research and development, although it was probably doing all it could reasonably afford at present. Further, it spent too much time talking about research and development and too little time doing it. On the other side of the coin, what the industry did manage to do, at least in the Water Research Centre and, of course, in at least one water authority, was done well. This was what really mattered, because in research and development, like in any other endeavour, the primary need was to obtain good value for money spent.

Verbal Discussion

MR. D.D. YOUNG (Severn-Trent Water Authority) opened the discussion by saying that, while agreeing with a great deal of what the author had to say, he would concentrate on the more controversial areas. First, however, he wished to endorse the comments made on the proposals for a general review of discharge consent conditions. This was obvious common sense and would be a great help to ensure that planners were able to direct resources so that better environmental value for money would be obtained.

The paper contained at least seven references to different aspects of water quality and public health. Current discussion of this topic was at least as relevant to the future of exisitng lowland supplies as to potential future supplies, and it should be given the highest priority by scientists wishing to make a contribution to major planning decisions. It was also an area in which the water industry was being subjected to a great deal of nonsense, particularly in relation to micropollutants. The essential structure of the argument was that firstly man put unnatural organic substances into river waters, and secondly that they were harmful unless proved to be safe.

Table I showed how much of the organic material found in lowland waters was derived from effluents, the remainder being of natural origin.

TABLE I. Sewage works derived TOC load as a proportion of the total TOC load at major water supply intakes

Surface water intake	Average flow		95% low flow	
	Effluent content, %	% of TOC derived from effluent	Effluent content, %	% of TOC derived from effluent
River Severn at Shrewsbury	0.5	3	5	13
River Severn at Tewkesbury	3	15	13	50
River Dove at Trent confluence	3	21	14	55
River Blythe at Whitacre	25	38	90	70

The most extreme case, the Blythe, had an effluent load similar to that found in the Thames and the rivers of the dry south-east and even in this case, three-fifths of the organic material presented at the water intake was of natural origin. It might be said that this material was "natural" and therefore likely to be harmless, unlike the effluent-derived material. However, chlorination changed this, and preliminary data from surveys of surface-derived drinking waters in Severn-Trent showed that the higher concentrates of chlorinated hydrocarbon substances were as likely to arise in upland water supplies as in lowland supplies.

It was worthwhile considering the quantity of organic material of unknown composition likely to be ingested over a man's lifetime from a highly treated surface derived source. At 3 mg/l of TOC, this amounted to about 200 g in a lifetime, compared with over 50 tonnes (wet weight) of foodstuffs. A fair proportion of this solid intake was of uncertain composition too.

Before expending large sums of money or accepting costly constraints on health grounds, it was essential to consider water-borne exposure as part of the total environment exposure and also the strength of evidence for, and probability of, adverse health effects in relation to cost. Taking the first point, colleagues would recall the furore raised in recent years on the subject of polynuclear aromatic hydrocarbons (PAH). Assuming water supplies to be at the limits recommended by the European Committee of the World Health Organization, the following indicated the relative equal intakes from different sources:

Air	140 µg/year	Leaf vegetables	60 µg/year
Potatoes	2 µg/year	Water	2 µg/year
Other root vegetables	2 µg/year		

He stressed that the other sources referred to were not rare components of the diet, such as highly-smoked scottish kippers, but the staple foodstuffs which everyone must eat. This kind of comparison was essential before any major expenditure was allowed to result from anxiety over health aspects of micropollutants.

To pursue the issue of strength of evidence for harmful effects, lead was an instance in which intake from water which exceeded the WHO European recommended limits could make a substantial contribution to total intake. A decision appeared to be being taken that all supplies must be remedied where this limit was exceeded and a rough estimate of the national cost was about £1,000 million. About £200 million of this burden would fall upon Severn-Trent. To put this figure into perspective, it would be equivalent to doubling the water industry's capital expenditure on water supply for a period of between five and ten years. Alternatively, it would cover three years of the total capital spending on the health service. It could even finance another Concorde programme. For all their concern with value for money in other lesser expenditure, planning and financial staff appeared to accept this proposed expenditure without question.

The evidence for any actual adverse effect on health from piped supplies was highly conflicting. For example, it was reported from Glasgow that identifiable symptoms could be observed, whereas it was reported from South Wales that the variation in lead levels in water which ran well above the WHO European levels could only account for about 13 per cent of the variation in the lead content of blood. Other evidence in the literature was equally conflicting and the statistical validity of some of the positive conclusions had been challenged.

The author had stated that where first draw lead concentration exceeded

0.3 mg/l, there was a high priority for remedial action. He himself questioned this and was of the firm opinion that far more reliable evidence of the effects on human health was required before an expenditure of £1,000 million could be shown as giving good value for money in terms of benefit to the nation's health.

Study of the public health aspects of water quality was certainly high on the scientific priority list in contributing to planning, but it required a much higher degree of objectivity and scientific rigour than was being displayed by many workers in this field.

The author's approach to groundwater abstraction was justifiably cautious but he could not follow the author's objection to the export of chalk water in itself. He thought that the essential feature was consideration of the water budget for the aquifer as a whole and the assessment of the environmental consequences of depletion against the social and economic benefits of securing water sources. The ultimate destination of the abstracted water did not seem to be particularly relevant. The author was less conservative about groundwater pollution and waste disposal. He did not share the author's enthusiasm for the work of the Institute of Geological Sciences and the Water Research Centre firstly because it had not yet been published and exposed to a proper level of public, professional debate and secondly, because he was sceptical about what he had seen in some of the preliminary glimpses which he had been given of this work. The high degree of protection of waters from pollution achieved to date was one of the major successes of recent decades and in view of the irreversible nature of most pollution of groundwater, it was essential to adopt a cautious approach. Did not the author agree?

The paper concluded by criticizing the EEC and though he shared the author's views, he believed that it would be wrong to infer that colleagues on the continent were not as aware of scientific, engineering, and financial reality. A deeper search should be made for the reasons for the strange proposals for directives relating to water quality and the environment emanating from the EEC. Was this not due to some fundamental failure of communication between the professionals in the water services in other member countries and their administrators and diplomats, and did the author see any ways in which there should be closer work with professional colleagues in other member states in making the output of the Commission more consistent with the facts of nature? Perhaps there was a need to develop a Community-wide association for putting the case to the Commission on the model of the various public authority associations within the UK.

MR. V.K. COLLINGE (Water Research Centre) added that the paper was both broad-ranging in content and contained a fund of good sense. As might have been predicted from the author's background, the emphasis lay heavily on aspects of river water quality and trade effluent control. He proposed to concentrate on three subjects which had received little attention in the paper, but first he dealt with a general point relating to the penultimate paragraph of the 'Introduction' (p.3 2). This definition of the place of science in the water industry was far too narrow. At the Water Research Centre, a wide range of scientific disciplines were now being employed to solve the problems of the water industry, e.g. the Centre now had material scientists working on the corrosion of pipelines and on new lining materials for water mains and sewers; microbiologists were studying the degradation of rubber jointing rings; operational research scientists were developing criteria for the renovation or replacement of water mains and sewers; and hydrologists were analysing the flows in rivers, aquifers and artificial draining systems.

Turning to another aspect of the paper, he observed that the study of water distribution and sewerage systems received scant attention and the only

brief reference dealt with plumbosolvency. It was now widely accepted that more attention was urgently needed to be directed to ageing underground assets and he was reassured to find that Mr. Walker had mentioned this in his paper (p.7 1).

Broadly speaking, there was a need to develop and implement techniques for assessing pipe conditions, and to develop improved renovation techniques. Work on these aspects was accelerating at the Water Research Centre and substantial scientific, as well as engineering skill, was being applied.

The problems of water re-use received only a passing mention in the paper which did not reflect the importance of this subject from the scientific viewpoint, from the implications for resource planning, and, of cours, from the financial implications. The practice of re-use was widespread in the UK, and the possibility existed that trace organic substances carried through into drinking water supply, some modified by chlorination, might be cancer-causing agents. The evidence to date was slight. However, in view of the lifetime exposure of millions of people in the UK to these substances, it was of paramount importance to determine what risk, if any, existed.

The Water Research Centre had a contract from the DoE to study this exceptionally difficult problem and the programme was costing about £200,000 per year and would extend for four years. Three different approaches had been adopted, and while the results from each were unlikely to be conclusive, the results alone in aggregate should provide sufficient evidence for decisions to be made about the future practice of re-use.

In conclusion, he referred to the subject of water quality and cardiovascular disease and his disappointment at finding no mention of this in the paper. This problem had been studied and restudied for over ten years now. The fundamental difficulty was that whilst statistical relationships could be identified in many places, including the UK, there was not any evidence of a causal relationship, and that was what was needed; to prove or disprove that water quality affected the incidence of cardiovascular disease. Some evidence could be found where water supplies had changed in quality, and the Centre was studying these under contract to the EEC. The implications that would follow if a causal relationship was established would be quite enormous.

MR. B.H. ROFE (Rofe, Kennard and Lapworth) took issue with the author on his statement that the '„water industry should adopt the general policy that water abstraction from chalk stream aquifers should be reserved to meet local needs..' (p.3 4). Was this really a suggested restraint based on scientific evidence?

The suggestion that the health of a chalk stream was dependent on the quantity of untouched groundwater storage only appeared to touch part of the problem. Although there had been errors of over-pumping in the past, the growing knowledge of hydrogeological analysis made it possible to make a reasonable forecast of the effect of future proposals. He, of course, entirely supported the author's introductory remarks with regard to the necessity for more detailed research into the ecological affects of a different pattern of flow.

Possibly one development that had had greater effect on the ecology of streams had been the tendency towards centralization of sewage treatment in upland rural areas. The Hertfordshire main drainage scheme and the current Hampshire scheme were examples where treatment and discharge of effluent from large upland areas had been piped to outfalls well down the river system. He asked the author if he would prefer such discharges to have been made higher up the river system.

The penalty of leaving groundwater storage untapped mainly reverted to the consumer, who had to drink a lower quality and more expensive water in consequence. The adoption of groundwater development schemes also had the positive advantages that they were generally unobtrusive, lent themselves to staged development, did not involve flooding agricultural land, and were not subject to sudden contamination. Why should man run the risk and not the fish?

A recent example was the development of the first stage of the Thames groundwater scheme for river augmentation, which was commissioned last year at a cost of about one-half of that of an equivalent surface water scheme. A full report on this, with an account of the initial operation during 1976, was to be covered at the symposium at Reading in April 1978. At present, it could be said that the consequential effects of pumping during 1976 had been shown to be negligible with very quick recovery thereafter, and a considerable improvement to the stream during operation. The environmental alternative to not using groundwater storage when it was available, was increased surface water storage with consequent loss of agricultural land and the considerable costs and hazards of down-river abstraction.

MR. R.G. TOMS (Wessex Water Authority) said that in general he supported the paper but was concerned about some of the comments made by an earlier speaker (Mr. Young) on the quality of the river Severn. These led to the assumption that the lower reaches of the river Severn were less of a problem for use in water supply than the upper reaches. This was not the case, as the downstream water user was always faced with much greater difficulty in producing a satisfactory water for supply and had to contend with many more complaints about taste and odour. These were almost certainly related to the amount of sewage effluent and trade waste present.

He asked the author to enlarge upon his comments about the setting of water quality objectives and the review of consent conditions. How did he see the liaison with the public and particularly with fisheries interests, developing when the Thames Water Authority discussed the short term review of consents?

Author's Reply to the Discussion

MR. H. FISH, in reply to the discussion, thanked Mr. Young for his useful and interesting opening of the discussion, and agreed with the points made regarding the excessive concern which seemed to be generated every time a new micropollutant was detected in water.

On the subject of lead in water supply systems, while he was absolutely opposed to any unnecessary expenditure on replacing lead distribution pipes and plumbing systems, he did not think that any water authority could sit back and ignore any case where the current WHO limits for lead in water were being exceeded regularly. In many such cases, remedial action might well be achieved without replacement of plumbing. Where replacement was necessary, and this depended on the circumstances of individual cases and not on predetermined policy, the replacement should be undertaken as soon as practicable.

Both Mr. Young and Mr. Rofe had commented on the views on excessive abstraction from chalk aquifers discharging to beautiful chalk streams for conveyance to distant points of demand. The ultimate destination of the abstracted water was important for two reasons. Firstly, local abstraction needs were usually minimal; secondly, if the abstraction was a large one, and the used water was returned to stream close to the abstraction point, at least it would

be possible to purify the used water to extremely high quality before return to ensure that both the volume and quality of the stream flow was reasonably maintained. He agreed with Mr. Rofe that increasing knowledge was giving a much better understanding of the consequences of heavy groundwater abstractions, but he was becoming increasingly dismayed that this knowledge was still being used selectively by people to justify excessive abstraction, coupled with measures designed only to prevent the extreme consequences of the excessive abstraction. The scientific knowledge was available now to demonstrate that one could still bring about a gross deterioration of a stream environment while stopping short of completely destroying this environment.

He made no apology at all for his comments about the EEC. He was quite sure, and history proved this, that practical experience of really effective pollution control in Europe, and indeed many other countries, was minimal compared to UK experience; and practical experience was a powerful means of distinguishing between management theory and management realities. The basic problem of the UK/EEC interface was that unreal environmental policy decisions were made before the UK became a member, and before the oil crisis fundamentally reduced the overall affluence of the developed countries. These early decisions must be adjusted sooner or later to give the flexibility necessary to contain changed and further changing circumstances; and the sooner the better.

Mr. Collinge had commented on the definition of water science. This comment was fair, but in the paper it had not been possible to spell out everything. There could be little doubt that the bulk of water management science, and indeed that at the WRC, related to chemistry and the life sciences. Again, on the subject of underground assets, Mr. Collinge's comments were accepted. However, he himself was no more persuaded by scares about ageing assets than he was by scares about micropollutants and he did not believe that the problems which arose were anywhere near as bad as they were made out to be. Most cases were usually overstated by their backers and played down by their opponents to establish where the middle ground of truth might lie. At least Mr. Collinge appeared to be close to the truth in his comments on ageing mains and sewers.

As for the statistical relationship between water hardness and cardiovascular disease, while it was perfectly right and proper that Mr. Collinge should refer to this, he himself would generate much more than a passing interest therein when knowledge advanced to the stage where mathematical comparsons could be supported by some better understanding of the fundamental relationship between the two variables. On this subject, and on any quality aspect of water re-use, he had complete confidence that the water industry as a whole would cope quite successfully and reasonably economically with the consequences of new findings. That was the industry's duty and, indeed, one of the main justifications for the existence of the Water Research Centre.

Mr. Toms' question was an interesting one. Liaison with the public and fisheries interests on the short term review of consent conditions in the Thames area was expected to go well. This review should in due course produce better results in rivers. The Thames Water Authority had nothing to hide, did not intend that any additional pollution should be allowed to occur, and would see that this intention was met provided the national financial situation did not deteriorate to such a level that all national hopes of social improvement were dashed. It was difficult to see how any water authority would encounter significant difficulties in liaison with the public on review of consent conditions based on those principles outlined.

4. WATER SUPPLY PROBLEMS IN LESSER DEVELOPED COUNTRIES

B.M.U. Bennell, BSc, DIC, FICE*

The Problem

The fundamental problem facing those engaged on water supply and maintenance in the developing world is to keep pace with the upsurge of demand. In Africa it is estimated that the urban population will increase from 96 millions at present to 312 millions by the end of the century, a threefold increase in twenty-five years. Over the same period the rural population is expected to grow at a slower rate, from 305 millions to 522 millions.

To meet the demand the water supply must expand at a far greater rate than the developed world has ever experienced. This will place a great burden on technical manpower resources and also demand vast capital expenditure. At the present time the most critical constraint is probably that of manpower.

Early Developments

In the period up to 1950 much of the impetus to improve water supplies came from expatriate communities. Reticulation systems were rapidly extended throughout the main administrative and commercial centres. The undertakings were often operated by expatriate staff strictly on the lines of those adopted in their parent countries. Firm discipline, both financial and technical was maintained. In the smaller centres, the undertakings were seldom autonomous and self-financing. They were usually run as a department of the municipality or Public Works organisation.

The actual operating costs were concealed in general government accounts, and any capital works were financed from central funds. Within their limits the water departments were efficiently operated. Typically each officer in charge of a department was given financial control of the agreed budget for capital or maintenance work, and was made personally responsible for any overspending.

Public Expectations

The period after 1950 coincided with a period of economic growth and rising expectation among the populations in the lesser developed world, many of them in the first flush of independence. There was a surge of population into the towns together with an explosion in the birth rate. For example the population of Nairobi doubled from 1962 to 1973 from 315,000 to 630,000. Over a similar period from 1961 to 1971 the population of Calcutta increased from 4.4 million to 7 million. This growth, with its consequent strain on the water supply system, occurred when expatriate assistance was being run

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down and localisation of staff was being vigorously adopted. Thus, at the very moment when experienced guidance and control to assist the expansion of the utilities was most needed, it was no longer available.

Whereas in villages, given a slower increase in demand, sources of supply were generally adequate and relatively uncontaminated, in towns the population, huddled together with ill-planned settlements without any sewerage system, had to draw their supplies from inadequate sources which became rapidly exhausted and increasingly polluted. There was a public clamour to improve water supplies, which in turn, compelled the governments to seek external assistance in the form of grants or loans for what was in fact a crash programme of water supply development projects.

This period also saw the resurgence of cholera in Indonesia in 1960 whence it spread rapidly westwards. After a gap of 75 years the disease reappeared in Africa, where between 1970 and 1974 it is estimated there have been 1 million cases of which 100,000 were fatal. The key to the control of cholera is environmental sanitation, in which the provision of a pure water supply plays a very significant part.

Benefits

In urban areas, a water supply system is essential in order to develop new townships and charges can be levied fairly readily to cover the cost of providing it. The financial viability of urban schemes is thus seldom difficult to achieve.

In rural areas, however, the concern is always with the improvement of supplies. Although the technical problems are often simple to solve, it is disappointing that the benefits conferred upon the population are often difficult to perceive and almost impossible to quantify. Usually the existing sources may have been used for generations but due to pressure on the land, they tend to become increasingly remote from the dwellings. In Western Sudan for example there are recorded instances of women driving donkeys ten miles to carry water to their homes. It is always assumed that more readily available, copious supplies will improve the health of the population but it has been found that unless there is a parallel programme of public hygiene education and the provision of at least minimum standards of sanitation, the general level of health does not markedly improve.

This difficulty presents a problem to aid donors who, in order to compare one type of project with another seek to quantify the return on the investment. Clearly it is difficult to quantify the time savings accrued by relieving the women of the chore of carrying water for a long distance each day. It is equally difficult to assess the value of the community organisation which may be required to operate even a small communal water supply. Finally it is often more difficult to quantify the improvement in the quality of life that the provision of an assured water supply confers.

Nevertheless it is now generally accepted that these benefits are real and that the cost per head of population for the supply of water, which typically in rural areas may range from £5 to £15 per head, is fully justified in order to improve the lot of the inhabitants. In rural areas it is sometimes possible to provide additional water for the cultivation of vegetables and other food crops. In these cases, the additional benefits can be readily assessed.

Technical Problems

It is difficult to generalise about the technical problems of water supplies in the lesser developed countries. The growth of cities and towns in historic times was often due to the proximity of adequate, copious water. Most of the large cities of the world are situated on rivers and those in the developing world are no exception. Development in the period of rapid expansion usually took the form of improvement of surface storage and treatment works. Since much of the engineering work was financed from external sources, designs were usually carried out by expatriate firms of consulting engineers who also supervised the construction by contract. In general, this course of action presented few problems. The extension of the reticulation system which was difficult to carry out by large contractors has frequently been left to the local functional department to carry out. For this reason the speed at which the reticulation system has been extended has sometimes lagged badly. Capital works have therefore remained idle for long periods and their maintenance has represented a drain on the revenue.

Conversely there are many instances where extensions of the reticulation system have proceeded without the equivalent development of the source. Given the difficulties faced on one hand by governments in raising capital loans to finance major works, and on the other, in resisting popular clamour for extending the existing systems, it has been the exception rather than the rule that the two have proceeded in step.

Traditional, well-tried methods were adopted in the design and installation of these new schemes. Well engineered on sound principles, the assumption was that although expatriate managers might be withdrawn, local engineers and technicians could be trained rapidly to take their place. Aid donors, particularly bilateral sources, assumed that the operation of the schemes would not present undue problems as they had run satisfactorily in the past and so little attention was paid to the question of technical and financial organisation, and special efforts were seldom made to simplify the technology adopted. In general, there was a tendency to adopt conservative designs on the prudent assumption that maintenance could not be carried out as regularly as in the past.

Logistic problems have frequently arisen, particularly in transporting large numbers of pipes through docks where handling is far from gentle, and frequently over very rough roads. With this in mind it is surprising that, even now, inadequate attention is often paid to packing and handling problems of large diameter water pipes. A breakage allowance of 15 to 20%, a figure frequently adopted, seems, at current prices unacceptably high.

Construction in remote areas is particularly difficult where there are no local contractors and the size of the work is not large enough to attract foreign firms. In this event, expatriate management teams are sometimes employed to work with the local department and organise construction by direct labour. For example, the Crown Agents through their Engineering Services Branch have provided such teams and have organized the supply of the construction plant, the provision and installation of the equipment. In another instance at Sikasso in Mali the consulting engineers provided the management team, recruited labour directly and themselves organized the provision of plant and equipment.

In rural areas construction problems are similar but more acute. Here normally local labour is available only when their farming operations permit. All equipment has to be hauled long distances over very inadequate tracks.

In Nepal, an extreme case where there are hardly any roads in the mountain areas, material has to be carried on to site on porters' backs.

Rural Water Supplies

A great international effort is now being mounted to increase the availability of safe, potable water to all rural communities throughout the developing world. Great emphasis is being placed on the employment of the appropriate technology in these schemes and much thought and effort is being spent on devising simple equipment for pumping, conveying and if necessary treating the water, which will be rugged and relatively maintenance free. Frequently the provision of better supplies involves the renovation of old wells. The design and construction of hand dug wells is now being extensively reviewed in the light of modern hydrogeological techniques, and the availability of new materials. For example, lightweight, well lining and screens, diameter 1.2 metres, have been manufactured in glass reinforced plastic and are currently being tested in West Africa. Unfortunately the undoubted simplification of transportation and installation is offset by the high costs of this equipment.

The hand pump, a familiar feature of the English village a hundred years ago, is now once more the centre of attention. Many ingenious modifications have already been devised which make full use of modern materials. One notable example of French design, has eliminated all moving parts with the exception of a pedal-operated air pump. In order to evaluate the performance and reliability of hand pumps to meet the upsurge of interest in them, the Ministry of Overseas Development has commissioned the Consumers Association (WHICH) to carry out an extensive laboratory evaluation of twelve different makes currently available internationally. Concurrently an extensive series of field tests is being carried out in the Northern Region of Ghana, where a number of different pump types have been installed in villages, and their performance closely observed.

Similar attention is being given to the design of the traditional wind driven well pumps. The models commercially available at present were mostly designed fifty years ago, and embody heavy castings which are expensive to produce and maintain. The redesign of windmills to enable them to be more easily constructed in developing countries, and to simplify maintenance, is being studied at a number of research institutions.

Pumps powered by solar energy have successfully been tried out in West Africa. The capital cost of this type of installation is high although running costs are minimal. An extended programme of field tests in Mauritania has recently been financed by the European Development Fund. Both these types require storage to cater for periods of no wind or cloudy days. This can add considerably to the capital cost and may offset the lo running costs.

Leakage and Wastage

As a general rule the rate of leakage in water supply systems in the developing world is very high. Typically in Lima, Peru, the estimated rate was about 55% in 1972, of the water supplied to the systems, but there are many instances of higher figures being recorded. The implications of these losses in terms of operating costs, lost revenues and waste of capital assets is very serious.

Part of the leakage system, namely that occuring up to the service

connections, is attributable to inadequate metering, and poor meter overhaul procedures. It also includes unauthorised, unmetered connections. But the greatest component is usually leakage from joints, faulty valves and broken or cracked pipes. Due to the inadequate and poorly trained staff in many undertakings, it is very difficult to improve these figures without a special training and sustained effort.

Consumer leakage results from the lack of control and inspection of consumer offtakes and plumbing standards within houses. In many cases pipes take off directly from the supply mains, and are subjected to full mains pressure. Another common fault is that overflow pipes discharge directly into the sewer, so leakage through faulty ball valves is not immediately apparent. The quality of valves, and fittings is often very poor so that they often perform badly.

The Ministry of Overseas Development are frequently asked to assist the setting up of a programme of leak detection and control in towns and cities overseas such as Lima, Barbados, Lahore, Jakarta, Kathmandu, Port Louis (Mauritius). We have recently established close formal links with the National Water Council, Training Division, who have been engaged specifically to study and reduce system losses. Where necessary the engineers in the field are provided with an initial package of standard pipes and fittings, together with the testing instruments, so that as soon as leaks are detected, they can be repaired without delay. The intention here is to demonstrate as quickly as possible the advantage of prompt and efficient leak detection.

Wastage is usually highest where connections are unmetered. In very hot countries consumers sometimes prefer to keep taps running claiming, rightly, that the water is thus cooler! Standpipes leak very frequently due to rough handling, and failure of the spring loaded "waste not" taps. The International Reference Centre for Community Water Supply, recently organised a seminar on general problems of standpipe design which considered inter alia the design of a more robust type of standpipe tap.

Payment for Water

In the developing world, water is regarded as a gift from God and therefore any system of charging seems morally repugnant. These scruples are being overcome although in rural areas the problem is very intractable. In some countries water undertakings have been slow to adopt the principle of metering supplies. Aid donors, especially the World Bank now insist on the metering of all supplies for new urban projects which they finance. The changeover to a fully metered supply is often very difficult. It is hard to induce the strict discipline for regular readings, the preparation of monthly or quarterly bills, the insistence on payment and a firm policy for cutting off supplies of those who are in arrears. In areas where the salaries of public servants are low, local pressures can easily be applied and it is easy to see how the metering system may be the subject of abuse. In some cases, the small amounts of water consumed hardly cover the costs of collecting the revenue generated.

There are instances of municipalities who have charge of water supplies regarding a water rate or charges as a means of raising general revenue. In towns which have no other rating system this view is understandable but it does mean that the water undertakings were milked of all the funds which were necessary for the adequate maintenance and normal expansion.

Where bilateral or multilateral aid is provided for new urban projects, donors frequently request that funds which are made available to the central government on grant or very favourable terms, should be lent by the government to the water undertaking at or near the prevailing interest rates. Some governments are very reluctant to do this but the reasons for this requirement are compelling. Firstly the undertaking, to earn enough to repay the interest charges, must operate in a financially efficient manner which in turn prompts attention to technical efficiency. Secondly, by ensuring that the water consumer pays the true costs of the supply, extravagent development schemes based on unrealistically low charges are curbed. Finally the government which retains the difference between the two interest rates, has an additional source of revenue and a financial interest in the efficiency of the undertaking.

Local charges are usually on a sliding scale with commercial charges being usually higher than the domestic rates. In some areas government institutions are not charged for water. This is to be deplored as it leads to substantial wastage and upsets the viability of the utility, but it is very difficult for the engineer/manager to take, say, the local Army commander to task for not paying his water rates.

In rural areas, it is more difficult to levy charges based on consumption. It is generally accepted that no-one should be deprived of water due to lack of income, with a result that the capital charges are often not passed on to the rural consumers. Whereas this degree of subsidy is accepted, to ensure that this free resource is not wasted, a nominal charge is desirable. The necessity of carrying water from a well or standpipe also tends to reduce waste.

Where running costs are incurred, for example to bring fuel to maintain supplies, charges either on a fixed rate per household or by means of a small charge per container are levied. Maintenance costs are frequently borne by the central authority. But this authority is often inadequately staffed and remote and inaccessible from the rural areas. It is now generally accepted that operation and maintenance must be left largely in the hands of the villagers themselves. This demands a sense of local cohesion which is often lacking, to organise the collection of dues and allocation of funds for the purchase of fuel and spares.

In urban areas, for reasons outlined earlier, there is often a lack of trained staff to operate and maintain the undertakings. Problems of training and retaining skilled labour are common throughout the less developed world where the emphasis until recently has been on professional training and where even highly skilled tradesmen tend to be regarded as socially inferior. This deficiency is now widely recognised and training schools for technicians have been set up.

Administration

In the first flush of expansion little attention was paid to administrative problems. The first agency which took a tough line on these was the World Bank. Being basically hard-headed bankers and imbued very much with United States experience they insisted more firmly than other aid donors that individual undertakings in urban areas should be self-financing and earned a reasonable rate of return on their capital to ensure that funds were available for maintenance and renewal of capital works when required.

This concept which seems so logical is even now in many parts of the

developing world not fully grasped. In some areas, notably in the Middle East, governments are reluctant to give control of this vital public service to an autonomous body which is not directly subject to their control. The fact that the control of water supply distribution gives political leverage and great local influence is not lost upon those in power.

To administer a rural water supply scheme effectively, it is vitally important to involve the community from its early stages, and to inculcate the idea that it is their scheme rather than something provided by a remote, albeit benificent, forgetful and overworked central organisation. The villages should decide for themselves within certain broad financial constraints what level of supply should be provided. If this enthusiasm is instilled and the project executed on a self-help basis, rural water supplies are generally successful, provided they do not embody a technology which is too advanced. The sense of community spirit thus engendered may have important social benefits.

Case Studies

In order to highlight the problems described in this paper, the situation in two cities in the lesser developed countries are described in some detail. The first example is Kumasi (Ghana).

The population of Kumasi and the peri-urban area has increased from 215,000 in 1960 to an estimated 456,000 in 1976, equivalent to an annual increase of 4.7%. A modern water supply system was installed in Kumasi about 1930 based on an impounding dam and treatment works, 10 kms from the high level reservoirs on the city outskirts. It is noteworthy that the pumping engines were Tangye gas engines, powered by producer gas obtained by burning local timber. These engines lasted for many years and were eventually replaced by electric pumps powered from the national grid. After extension to the treatment plant in 1954, the capacity is now about 13 Mld.

In 1971 the construction of a second impounding dam and treatment works was completed at Barikese to designs prepared by British consulting engineers. A pumping main 910 mm diameter and 16 kms long carried water to the city. Provision was made for the expansion of the works from an initial capacity of 55 Mld in stages to an ultimate 110 Mld. A project to increase the capacity up to 82 Mld is now under urgent consideration.

This expansion is long overdue as the existing reticulation network has been extended throughout the city into the rural areas to serve villages as far as 24 kms away. Already it has become impossible to supply some of these rural areas without curtailing supplies to the city. Restricted supplies have resulted in some rural industries such as battery chicken farms being closed down. Formerly it was possible to supply these villages by means of water tankers but at the present time due to the lack of vital spare parts only one of the five tankers was operational and in general the tanker supply service has been found to be very uneconomic.

Up to 1958 the Owabi headworks were operated as part of the Hydraulics Division of the Public Works Department by four expatriate engineers assisted by Ghanaian engineers and about 300 labourers. Many of these were engaged in keeping the reservoir clear of water hyacinth and cutting timber for the gas engines. As far as possible all the repair work was carried out on site and the spare parts were locally manufactured. Strict discipline was maintained over maintenance procedures. For example, an inspector walked along the pipeline into the city every day in each direction, seven days a week with

the exception of an annual two week holiday. By such control measures as these, leakage was said to be about 10%. At the present time the access track along the pipeline has grown over and it is impossible either to drive or walk along it. Overall losses are now about 25%.

Maintenance of the system is not good, due to the difficulty in keeping trained staff. There are two training schools in the country providing courses for pump and filter attendants and waterworks technicians. The quality of training is thought to be capable of improvement and at the present time arrangements are being made with the help of the Training Division of the UK National Water Council to assist with this aspect.

House connections are carried out by water department staff, and internal plumbing is generally in accordance with a draft code.

The new treatment works at Barikese are well maintained. However, there is the continual problem of the availability of spare parts for the machines, instruments and control gear, due to the complications introduced by the need for strict control on foreign exchange expenditure. There is a growing problem with the control of water hyacinths, which not only might block the siphon spillways during a flood, but are altering the biological content of the water, increasing treatment problems.

The undertaking is now self-accounting, and in the city all supplies are metered. Bills are submitted regularly and there is a good record of payment. Cut-off procedures for defaulters have recently been more rigorously enforced. Charges are as follows:-

For standpipes in villages	50p per house per month. This rate is very difficult to collect in practice.
For houses without meters	£1 per month.
For houses with meters	4.5p per cubic metre with a maximum of £2 per month.
Commercial undertakings	10p per cubic metre.

Within the city the system is financially viable but in the rural areas only about 30% of the supplies are metered and these sections operate at a financial loss.

The second case study is of the water supply to Kathmandu, the capital of Nepal. Here water is abstracted from five springs around the plain in which the city lies. The reticulation system has grown up in a haphazard manner and each of the sources has its own treatment works. These are of a conventional nature but are old fashioned, poorly designed and operated by untrained personnel. The population of Kathmandu is now about 265,000 of whom about 50% are served with house connections, 35% by standpipe and 15% have no supply at all. Tariffs are at the rate of 2.3p per cubic metre for up to 10,000 litres per day and 3.6p per cubic metre in excess of this figure. There are also many charges per connection ranging from 23p per month for a 12 mm diameter pipe to £55 per month for a 100 mm diameter pipe.

The utility is managed by the Water Supply and Sewerage Board which is an autonomous body, with an annual revenue for 1975/76 financial year of £90,000. It has a staff of 18 engineers, 11 overseers and 9 administrators. There is a very severe shortage of trained manpower to operate the system at all levels. This shortage is exacerbated by government rules which require tradesmen to

resign from the service and so take a lower pension before they can be reappointed in a higher grade. The limited staff are fully engaged either in dealing with emergency breaks or in completing additional extensions to the network. There is no programme for routine maintenance and more than 50% of the valves and hydrants are currently said to be unserviceable. At the present time supplies are inadequate to serve the system and pressures are very low. In many areas the system is completely drained twice a day.

The physical condition of the system is very bad. The water unaccounted for amounted to 75% of the supply in 1973, namely 3 litres lost for every one supplied. There has been some improvement since then. Wastage is due not only to leaking pipes and connections but to poor workmanship, badly installed ferrules and sub-standard pipes and fittings. Given this high rate of leakage and the fact that the system pressures are low for much of the day, the possibility of serious contamination due to the ingress of polluted groundwater is very real.

Private connections are the responsibility of the householders. There is very little supervision or control of the manner in which these are effected. In some instances it has been found that plastic insulating shields from electric cables have been used as supply pipes.

A major project to improve the supplies to the city is now being implemented. In the immediate future this will create further difficulties in the reticulation system as higher pressures will be maintained for longer periods, putting an even greater strain on the network.

The British Technical Co-operation programme has for some years been assisting the water undertaking in a training programme for maintenance, and leak detection and in the operation of the treatment work. A senior British Water Supply engineer has also been advising the General Manager on general technical matters, for the past three years. This assistance has resulted in an improvement in the efficiency of the undertaking.

Conclusion

It will be evident that the main problem facing the lesser developed countries is how to build up the administrative and technical branches of their water supply undertakings and at the same time coping with unprecedented rates of expansion. The prime need therefore is the training of staff at all levels and in all disciplines.

The water undertakings in developed countries are already offering considerable help by providing opportunities for practical training. In the UK consideration is now being given to the question of making some more formal arrangements to this end. The possibility of twinning arrangements between a UK undertaking and one of similar size overseas is also being considered. This would facilitate both a regular interchange of staff and a training programme. The personal relationships and technical back-up which might be developed through such an arrangement would be a great advantage to the overseas undertaking and might prove stimulating and rewarding for the home-based organisation.

The need is such that radical and imaginative solutions to these problems are urgently needed and fully justified.

DISCUSSION

Author's Introduction

MR. B.M.U. BENNELL, in introducing his paper, said that having read the other papers comprising the Symposium and having heard the discussion on the first three, he was conscious that his paper did not rest easily with the others.

To some extent this epitomized the vast difference between the problems of public health engineering in developed and under-developed countries. On the one hand there were discussions on planning, financial problems, priorities, and the like, and on the other there was concern with public expectations, social benefits, and, in the very extreme case, hand pumps. He believed that the gulf between the two was widening. It was a sad fact that in spite of all the massive injections of foreign aid and capital over the past 25 years, the poor countries were tending to become poorer and the rich were at least holding their position, if not exactly getting richer. He did not want to dwell on this theme, but said that it had been the subject of innumerable conferences, seminars and heart-searching in high places.

Within the under-developed countries themselves, the same pattern was repeated. Generally, such development that took place was having the effect of polarizing distribution of wealth. Contrary to the hopes expressed 20 or more years ago, there was little evidence of the "trickle down" effect. For example, the construction of a fine new modern road from the countryside to a town was not having the effect of increasing the prosperity of the countryside, but rather acted as a drain by which people from the country were drawn into the town to dwell in slums on the town's perimeter. Notwithstanding the generally low housing standards in the slums, there was usually access to a water supply and possibly electricity, medical facilities, and education for the children. In view of this sad fact, the Ministry of Overseas Development, in common with other major donors such as the World Bank, was now turning its attention directly to the problems of the poorest people in the poorest sectors of the economy: this was almost invariably the rural sector. He hoped that this would serve to explain the reasons for highlighting the problems of rural water supplies in the paper. As he had explained, there was currently a great upsurge of international activity in this field.

Social and administrative problems were paramount. Motivation to install and, above all, to maintain a project after completion was very difficult to instill. Much thought was being given to the use of the appropriate technology but there was little chance of a spectacular breakthrough in this direction. The technologies of rural water supplies were in any event straightforward and simple. Nonetheless, the Ministry and others were making considerable efforts to improve and refine the existing equipment and plant.

Concerning economic aspects, the Ministry of Overseas Development and other donors had in the past paid great attention to quantifying the economic benefits of public utility projects. He hoped that the paper emphasized the difficulty in this respect where the rural sector was concerned, and also the problems of obtaining any monetary return on the investment. It had generally been agreed that a subsidy for the rural sector was essential. Nonetheless, it should be borne in mind that the aggregate cost of the development and maintenance of water supplies in the rural sector could be high, and clearly for many countries there must be an upper limit.

It was important to bear in mind that money spent on social projects did not directly contribute to the national income. In a perfect world, development should be the other way round: namely, increase the national income first and then provide what were essentially the social services.

In urban areas, the main problems were those concerned with operation and maintenance together with continual expansion which was usually on a piecemeal basis. Here there was a general pattern of lack of control by the undertaking, poor standards of both connections and internal plumbing, and very loose financial and accounting control. However, there were some notable exceptions but even these were exposed to constant dangers, given weak central administrations and possible political interference.

Some elaboration was called for on the subject of training and technical co-operation. He had stated in the paper that there was a paramount need for assistance to undertakings in the lesser-developed countries. This took two forms, and the first was training in the UK; the second was guidance by means of technical co-operation in the field. The Ministry was grateful for all the opportunities afforded for the practical training of overseas engineers in this country, mostly in water undertakings. On the academic side, apart from general courses in public health engineering, the Ministry was giving financial guarantees by 12-week diploma courses at Loughborough University in public health engineering for hot climates.

Finally, it might be of interest that in all probability one of the five key topics which had been selected for the UK contribution to the United Nations Conference on Science and Technology to be held in 1979 was to be public health engineering. It was not inconceivable that as a result of putting these goods in the shop window, there would be some pressure to step up efforts to transfer technology in this field. He made no apologies for lobbying for help in this direction. He believed that there was both a long term interest and a moral duty to help lesser-developed nations in these endeavours.

Verbal Discussion

MR. R.L.H. SATCHELL (Severn-Trent Water Authority), in opening the discussion, said how valuable the paper had been in setting the UK water industry in a world-wide perspective. The marked contrasts between the UK and developing world called for particular comment.

A colleague and his companion had recently returned from an expedition to Nepal, including Kathmandu, and had suffered unpleasant gastric upsets. In addition, the companion had developed bacterial meningitis, causing him to be away from work for a month. In diagnosing the cause, the medical authorities told him that his illness had arisen from drinking water contaminated by rats. This result of the sort of chaos outlined in the paper underlined the plea, made earlier by Mr. H. Fish, to avoid becoming complacent about the quality of water supply in Great Britain.

The most striking contrasts were perhaps those of population change: 207 per cent growth was forecast for Africa by the year 2000, as compared with about 6 per cent for the UK in the same period. Water authorities in England and Wales were more often joining together with others in joint consultation with all those involved in planning to ensure that forecasts were as realistic as possible. The question was, therefore, would the suggested increases in population overseas actually materialize? If they did, how would the roads, schools, medical facilities, industry, and above all, the food be provided? To what extent did the Ministry of Overseas Development lend their weight to others in pressing jointly for an overall strategy that was credible? It had been shown in the UK that water authorities were in the business of providing advance capacity, i.e. they had to construct essential water services in advance of need. The important economic question was to get the timing right and avoid the evil of capital resources lying idle for long periods, as mentioned in the paper. Without a co-ordinating policy across the important areas of the economy, it would not be possible to do the job properly, with a consequent waste of resources.

The contrast in technical advance might yield a lesson for the UK, which was moving towards ever-increasing technical sophistication. This progression led to the employment of less people who must be more highly skilled: but it might be that in the present and future forecast circumstances of steadily-maintained, high unemployment, water authorities should move towards simpler and more labour-intensive technology. With the average cost of employing a person capitalized at about £35,000, it might sometimes be more economic to do so than to invest in advanced technology.

Lastly, the intriguing allusion in the conclusions to using UK expertise to help the developing world should be vigorously explored. Already one water authority was working with consultants, offering management expertise in overseas commissions, while the former chief executive of another authority was at present advising the Indian Government on water services administration. How did the author see this co-operation developing?

MR. C.C. KERR (Sir William Halcrow and Partners) added that the two case studies had clearly illustrated the wide field of technical and financial problems experienced in the lesser-developed countries.Population growth was indeed a major factor in the rapid rate of growth in demand for water in developing countries, and urban drift was almost inevitable if pressure was to be taken off limited land resources. To minimize the grave problems of unplanned squatter development, it was common policy to attempt to provide "site and service" building plots for the increasing urban population. Initially, water might be supplied through sellers' kiosks but as standards improved, there was a demand for individual standpipes on plots, followed eventually by the internal plumbing of houses.

Universal metering appeared to be the only current solution for the efficient distribution of urban supplies in tropical countries, largely because of the great seasonal demand in the summer months for garden watering, including crops and vegetables, and also to limit wasteful use. Even where supplies were

effectively metered and charged at an economic price, the peak month demand might typically be 25 per cent greater than the annual average, and the peak three day demand 40 per cent or more. Thus, despite metering, peak seasonal demand might often result in reduced or even negative pressures in the distribution system, with consequent dangers of pollution. This might be minimized by a seasonal tariff surcharge, or by the expedient of flow restrictors at the meter. Individual storage, as mentioned by the author, would assist greatly, but in tropical countries there must be careful supervision to prevent contamination.

The influence of the international lending agencies in encouraging the charging of full costs, including loan charges, in conjunction with metering, had in turn led to the introduction of economic charges for water. In the case of "lumpy" capital extensions, a measure of financial assistance might be necessary in the early years, together with a two-part tariff with a relatively low metered charge to encourage consumption. Thereafter, the tariff should be adjusted with increasing emphasis on the metered charge so that by the time the next extension was due to be started, consumers were able to signify their requirements at the future price: thus correct timing for the project was ensured. A major difficulty, which was not confined to developing countries, was to make timely changes in water charges.

Furthermore, with universal metering, installation, maintenance, and billing,a great burden was placed on the organization, and the system could only operate where bills were presented promptly, preferably monthly, and where the sanction of discontinuing supplies for non-payment could be imposed as a routine measure. This was not always possible, as was shown by the case of the presumably hypothetical army commander mentioned by the author. This could render metering a useless exercise.

He requested the author's comments on alternative methods of efficient distribution and demand control, particularly for low income groups where a large proportion of meters might register only 3 or 4 m^3/month. Such supplies were effectively cross-subsidized, and the sole justification for metering them was waste control.

The processes of water treatment and distribution were essentially simple and involved a relatively low technology. In a developing country, plant must be simple and robust and basic essentials must receive priority, such as a low turbidity filtrate and chlorination to obtain a free residual at the furthest offtake. The main objective of the appropriate technology approach was to make the best use of resources by keeping capital costs down through more labour-intensive methods and by simplifying operation and maintenance. However, labour-intensive methods might require even greater management skills, bearing in mind the unremitting care and attention that was involved with checks and counter-checks, so essential in water supply.

He agreed with the author's conclusion that the main problem was one of organization and training. Many major water supply schemes in developing countries were inefficient or inoperative because of the inability of the organization to cope with operation and maintenance. In some cases this had been caused by installations that were too sophisticated; but in others, as indicated by the author, routine techniques, such as waste control, could alleviate the difficulties experienced. The solution required political will and the co-operation of the people, particularly if universal metering and billing was to be effective.

To his knowledge, the National Water Council together with UK water authorities, had played a great part in assissting formal training of super-

visory staff from overseas. There was still a great need for in-service training of waterworks personnel, and, unfortunately, it was not always appreciated by developing countries that the most difficult posts to localize were those on the supervisory or lower management level previously filled by expatriates with long experience in the industry.

He fully endorsed the author's conclusion that radical and imaginative solutions to the problem facing lesser-developed countries were urgently needed, and noted with interest that the possibility of twinning arrangements between UK and overseas undertakings was being considered. Much could be done by the secondment of staff of the right calibre and he was sure that UK undertakings and consultants could themselves learn much by helping to solve these problems.

MR. M. GREHAN (Private Consultant) congratulated the author on his paper, which summed up concisely the problems which were met in lesser-developed countries: the benefit which he reaped from his long experience in technical assistance was apparent from beginning to end. He also congratulated the Symposium organizers on their enterprise in including a paper dealing with the provision of water supplies in the world's many hardship areas which contained a high proportion of people suffering from serious privation: the temptation to concentrate on the UK water industry was no doubt considerable. On a global scale, at least one-fifth of the total world population was without safe or sufficient drinking water, while the proportion climbed to three-quarters in rural areas. In many countries, less than one-half of the urban population and less than one-tenth of the rural population were served with an adequate and safe supply.

He had recently undertaken several missions for the UN Food and Agriculture Organization, the UN Development Programme, and the World Food Programme on water engineering aspects in India, Pakistan, Syria, Iraq, Egypt, and other developing countries, and so had been able to obtain a reasonably clear picture of the water supply problems confronting the rural populations in these countries. The missions had been mainly concerned with irrigation schemes, many of which were very large, for increasing food production. These projects were undertaken with financial and technical assistance provided, at least in part, by donor countries under bilateral agreements or through international organizations such as the World Bank, the IDA, and the EEC. The general planning and engineering designs were undertaken by the recipient governments in collaboration with foreign consulting firms or agencies, while the preponderantly social aspects, such as settlement or resettlement of local populations, farm layouts, field channels and drainage, village construction, and rural water supplies, were generally left to the government or local authorities to execute to the best of their ability. In some cases, a fair, if delayed, standard of completion was achieved but frequently the work that was involved, although technically straightforward, demanded a high degree of planning and organization, and was rarely adequately executed: so the project started off with a back-log it never managed to make good.

The most neglected work was generally the provision of safe domestic water supplies. On an irrigation scheme, water of a kind was always available and the need of a separate, safe domestic water supply was easily forgotten. Furthermore, polluted drinking and washing water was just another hazard that had always existed side by side with diseases from waterborne infestation such as bilharziasis, onchocerciasis, and malaria. What, it may be argued, was the use of improving the first without eradicating the others?

Yet it was essential, in developing countries, to improve standards of water cleanliness and availability with all possible speed. Water was the key resource contributing to human well-being and health; and any advance in the

combat against the main killer diseases in hardship areas needed to be triggered off by a demand for, and a realization of, better control and quality of water, both for human needs and for agricultural production. This obvious planning requirement might provide a basis for useful co-operation between water supply engineers and irrigation and general water development engineers. All the major consulting engineering concerns had considerable water engineering interests and experience abroad, and it seemed that one significant way of improving rural water supplies in developing countries might be to evolve, under the auspices of the two Institutions (IWES and ICE) and in conjunction with the Ministry of Overseas Development, a series of technical recommendations for the provision of efficiently controlled and safe water supplies in regions that were dependent on irrigated agriculture for food production.

MR. D.G.M. ROBERTS (John Taylor and Sons) commented that a reliable supply of good quality water provided many additional benefits, including enabling water-consuming industries to be established and increasing industrial production through reducing the incidence of disease among operatives and thereby reducing absence. However, he wondered if, in situations where lack of funds prevented the provision of an adequate supply of good quality water, the author felt that a plentiful supply of water of inferior quality was preferable to a restricted supply of water of potable quality, particularly when it was recognized that it was often possible to acquire a natural resistence and immunity to disease.

One aspect of expenditure that was taken for granted in the UK, but which was often missing overseas, was the proper maintenance of services. In one particular town he had found that nearly two-thirds of the water put into supply was lost through leaks etc., but by the introduction of a waste-detection and repair programme, an inadequate and intermittent supply had been transformed into a round-the-clock supply with reasonable pressure. This was an example of the significant improvements which could sometimes be achieved for relatively little expenditure.

In the UK about one-half of the total water put into supply was consumed for sanitary purposes. Many overseas towns with municipal water supplies did not have a sewerage or sewage-disposal system, and one of the factors against the introduction of a water-borne sewerage system was the requirement for an associated expansion of the water system. He understood that the World Bank and other international agencies were presently considering non-water-borne systems for under-developed countries, and he would be interested to know the author's views on these possible developments.

The difference between the problems faced overseas and in this country was highlighted by a comparison of GNP and rate of population growth. In the UK, there was a GNP of around $US5,000 per capita and a static population, whereas many developing countries had a GNP of $US200 to $US500, while urban populations were doubling every ten to fifteen years. Thus, such countries had minute resources with which to tackle problems that were considerably greater than our own.

MR. J.F. PHILLIPS (Southern Water Authority) dealt first with the statement that the general level of health did not rise when a pure water supply became available. Most Public Works Department labourers in Kumasi were northerners, many of whom suffered typhoid fever when visiting home probably because they had lost their immunity whilst living in Kumasi where they drank pure water; this must also apply to many other temporary residents, such as students in boarding schools and colleges.

He described the suffering caused by the Guinea worms imbibed in water

from ponds or streams and spoke of the need for wells, which also prevented bilharzia spreading; wells with buckets on ropes rapidly became infected with typhoid etc., and covered wells or boreholes with reliable hand pumps were essential. Concerning pumps, the unanimous finding of water engineers in West Africa was that pumps with cow-tail handles were short-lived, but the Godwin X-type gave satisfactory service. He protested that pumps for West Africa should be tested in the field by West Africans, not in an English laboratory.

Throughout Nigeria, local workmen sunk wells competently and cheaply; the method involved digging a 1,400mm diameter shaft to the water and then lining with *in situ* concrete 75mm thick from bottom up. This ensured that money was not wasted on lining dry wells. Having lined the shaft, a concrete kerb was made and lowered into the well and steining erected as further sink ing took place, often at the end of the dry season.

The author mentioned that the developing countries generally had high unemployment, low GNP, and external payments problems, yet most modern waterworks had rapid gravity filters employing coagulation with sulphate of alumina whose cost (in 1960) per Mld was equal to the pay of 10 workmen. The cost of *p*H correction and sterilization were of the same order. Clearly, slow sand filters would be more appropriate technology except for large works. Also, many waterworks had large slow-running diesel engines driving centrifugal pumps via speed-increasing gears: few African artisans had the skills these engines demanded, but there were hundreds who were ably maintaining high-speed automotive diesels. These small engines coupled direct to centrifugal pumps were much cheaper to buy, transport, house, install, and run than the big engines, and they would be more appropriate technology on all counts.

MR. D. DAVIES (private consultant) wrote that this paper was revelationary rather than revolutionary and it was a "must" for those venturing overseas; for it was becoming increasingly difficult for the new expatriate to help effectively now than it was before. There were two reasons for this.

Firstly, there was the ever-growing gap between the "haves" and the "have nots". Without very deep thought and sympathetic understanding it was almost impossible for the new expatriate to provide a sound working answer to the local problems, which were so far beneath his experience. In the terms of the west, he knew the answers; but within the severe constraints of the developing country, the practical solution often eluded him. Given a gross income per head of £60 per annum, tribal starvation, and a western solution costing £100 per head, where should he start? If he waited a decade, only to find that the population had doubled, what then? By comparison, the UK drought measures of 1976 had brought discomfort rather than having deferred death.

Secondly, modern western education and training, geared to the needs of a sophisticated society supported by an alien culture, was a handicap to the provision of rural water overseas. Moreover, such work brought neither esteem nor medals. Thus, many who were nurtured on homogenized and computerized water, encouraged by their indigenous pupils, took there symphonic instruments across the desert and wondered why the locals failed to produce permanent water music! Top equipment made top men better: it made below-average men worse, no matter where they came from.

The solution lay partly in a return to those water basics engraved in western water history which matched the tribal skills. A century ago, Britain too was a developing country. In 1869, Manchester (which was typical of the then fashionable, intermittent water systems), was bleeding, but never reaching its water death with a leakage rate of 55 per cent, like that of Lima, Peru, in

1972. Then, illicit connections, cut-offs, and handless meter dials were common-place, just as in the 1960s there were more cut-offs in Istanbul than there were total connections. The recent African cholera epidemic was but a carbon copy of those outbreaks in Europe during the last century, when in 1892, 260,000 died of the disease in Russia alone. Like the pre-World War II opposition to chlorine in Scotland, the strong resentment to fluoridation in post-war England was not so distant from the recent tribal rejection of desalinated water, the rejection being based on the belief that it made women barren. Instead of being pleased, the tribes were offended. If history was examined, it would be found that there was no present or future, only the past being repeated over and over again.

This study of his own water history would give the expatriate an improved balance, modify his expectations, help him to identify better with those in need, confirm him in the belief that half a loaf is better than no bread at all, prove to him that a modest advance without regression was superior to a thousand year advance which was only transient, make him realize that one good water main was worth many a fine boardroom, and would lead him to discover that without proper management and regular monitoring, half a loaf would become crumbs. What it would not tell him was how to bridge the hierarchical time gap between a well-insulated chief executive of the new twentieth century water corporation and his remote tribal subordinates the other side of the rainbow, all within a non-delegatory culture like that of the UK water authorities of the early nineteenth century.

Author's Reply to the Discussion

MR. B.M.U. BENNELL, in reply to the discussion, wrote that Mr. Satchell's contribution went to the root of the problem facing all the lesser-developed countries, i.e. that of population growth. This was indeed the concern of the Ministry of Overseas Development which had recently set up a special unit, the Population Bureau, to work with all other agencies who were trying to assist with this problem. To illustrate the gravity of this task, the population of India had doubled since independence in 1948. If it continued to increase at this rate, it would double again in 30 years' time.

Mr. Kerr was rightly concerned about the distribution and demand control in circumstances where the revenue from metered supplies was less than the cost of collection. One way of coping with this was by means of supplying water free or at a nominal charge per container via communal standpipes. Much thought was being given to the design of an unbreakable "waste not" tap, or alternatively one which would give a metered amount of water by the insertion of a token in a slot, tokens being purchased in advance.

Mr. Grehan had emphasized the need to look at the total needs of a community when planning development projects. This was now in line with the Ministry's current policy and, where possible, the provision of pure water alongside major irrigation developments was being considered.Unfortunately, the small, packaged treatment plants available on the market, which were relatively cheap to buy and easy to install, also required specialized maintenance which, as emphasized in the paper, was seldom available. It was necessary, therefore, even at the price of some increase in capital costs, to rely on simple, straightforward processes.

The question of the degree of treatment which should be incorporated in rural water supply schemes was mentioned by Mr. Roberts. Clearly, each proposal must be judged on its merits, but it should be emphasized that the pro-

vision of treated water would not, in itself, result in an improvement in health. Education in social hygiene was also essential. Nevertheless, the first step was to provide a relatively clean source of water, free from bacteriological impurities.

The problem of sewerage and sewage treatment in poor areas was difficult. There seemed to be no alternative to water-borne sewerage in urban areas which was completely and technically effective. The night soil collecting system, much used in colonial times, required a high degree of discipline and control, both of which were frequently lacking in local administrations. Furthermore, the concept was widely regarded as socially unacceptable and repugnant, the more so if the suggestion of incorporating such measures was made by an expatriate organization or aid agency.

In his interesting contribution, Mr. Phillips touched on a number of important side effects, often overlooked, when treated water supplies were introduced. On the question of hand pump testing, the comparative tests now being carried out in Britain supplemented a similar field study recently completed in Ghana, financed by Canadian aid. The object was to get a truly objective comparison under precisely similar conditions of testing.

He fully agreed with Mr. Phillips' plea for the reintroduction of slow speed diesels where appropriate for use in water supply schemes. Unfortunately, there were only a few, if any, manufacturers nowadays who made this type of equipment.

Mr. Davies had added an appropriate peroration to the message which he himself had been trying to put across. The problem of water supply to communities overseas, especially those in remote rural areas, required a completely fresh approach and demanded imaginative and radical solutions based on technology which was appropriate to the need and commensurate with local skills.

5. A METHOD FOR INTEGRATING ENGINEERING AND ECONOMIC PLANNING

S.H. Hanke*

INTRODUCTION

Until recently, economic policy debates on questions of urban water supply were largely benign because, among other reasons, the water industry in the industrial world had performed well. Now, however, water authorities are increasingly required to justify more rigorously expanding their systems.

I shall argue here that by combining the engineering and the economic analyses which they usually conduct separately in order to justify expansion, water authorities may much improve their investment planning.

CHARACTERISTICS OF THE WATER INDUSTRY

In most parts of the world *per capita* water use is growing rapidly. This demand varies with the seasons and peaks during the summer. In the extremely capital intensive business of supplying water, the real cost, i.e. excluding inflation, of more water provided by new schemes exceeds that of water delivered by existing works. Also, supplying new water costs more in the summer than in the winter.

The water industry has generally practised what we will call "supply management". Managers forecast water use without explicitly considering how price, for example, may affect consumption. They often arrive at these forecasts of water "requirements" by simply multiplying the projected population of the service area by the estimated average *per capita* use. By projecting deficiencies in the supply system itself, planners then decide when and how much capital should be invested in new works.

Supply management, therefore, sees water use as a "requirement" that must be met and is outside the control of management. Its adherents fail to appreciate the relations between the economics and the engineering of water systems; that is, they fail to take proper account of how economic policies (e.g. tariffs), water use, and the design of new works may affect one another.

If supply management persists, water authorities will have to commit ever-scarcer capital to ever-increasing demands. In many parts of the world, environmentalists, consumers, and public authorities competing for scarce resources are questioning the need for new water works.

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In contrast to managers of supply, who do not "properly" control water demand and thus tend to over-invest in system capacity, some managers explicitly use prices, regulations, and other policies to control demand and thus avoid expanding their systems: but these "demand managers" tend to encourage too much conservation and too little investment.

INTEGRATED SUPPLY-DEMAND MANAGEMENT

The shortcomings of supply and of demand management can be avoided by what I call "integrated supply-demand management." This method aims at increasing supplies until the cost of supplying another ML equals its benefits. Thus, by "properly" balancing supplies and demands, integrated management finds the "proper" system capacity.

Let us look in turn at two types of integrated supply-demand management - administrative planning and the price system.

Administrative Planning

In administrative planning, water authorities attempt to expand system capacity until the benefits from another unit of water equals its costs. Besides applying cost-benefit analysis to determine this "proper" capacity, planners impose a variety of rules, regulations, and incentives to ensure that consumers' demands do not exceed this capacity.

In practice, however, administrative planning falls seriously short in two ways:

1. Planners have no reliable way of estimating the benefits from urban water supplies. (1) Hence, cost-benefit analysis cannot find the "proper" system capacity.

2. Planners have no reliable way of devising non-price rules that allocate water to its highest valued uses.

The Price System

Here water authorities use prices as signals to consumers. Prices are raised to discourage consumption and lowered to encourage it. Of course, water authorities must somehow determine the "proper" price.

To arrive at the "proper" price and the "proper" system capacity, water authorities must:

1. compute the cost of supplying another unit of water, i.e. compute the marginal cost of water;

2. meter supplies so as to include a price per unit in the tariffs; and

3. set the unit price equal to the marginal cost.

Prices set equal to marginal costs are neither punitive nor permissive: they simply reflect the scarcity of the resources used to supply more water. Punitive prices exceed marginal costs and lead to excessive conservation. Permissive prices fall below marginal costs and lead to wastage.

Using marginal cost pricing and the price system, then, water planners do not need cost-benefit analysis. Instead, each paying consumer assesses his own benefits and costs. If he requires another unit of water, he must pay its marginal cost. Since he will not choose to buy at a price, i.e. the marginal cost, that exceeds his benefits from the extra unit, water will find its most valued uses.

INTEGRATING ENGINEERING AND ECONOMICS

Water authorities call upon two kinds of planners: engineers who design works that are to supply a forecast amount of water at a stipulated reliability; and accountants or economists who estimate the costs to be incurred during the planning period (revenue requirements) and who design the tariffs (both *structure* and *level*) that are to meet the costs. The engineering and the economics are usually done separately.

To combine engineering and economics effectively, water authorities should consider, for example, how tariffs affect demand, how demand affects engineering costs, and how engineering costs might affect tariffs.

We have seen that the price system allows consumers to decide how much water, at a certain price, they will buy: but unless planners can somehow relate certain prices to certain demands, they cannot adequately plan for new works, i.e. they cannot integrate economics and engineering. We now turn to price-demand relations.

Price-Demand Relations

In economics the law of demand says that, *ceteris paribus*, the quantity of a commodity demanded will decrease as its real price increases; or, if the real price decreases, the quantity demanded will increase. There have not been any exceptions found to this law among the world's commodities, including water.

The sensitivity of water use to changes in the real price of water is known as the price elasticity of demand. The price-demand relationship can be expressed as follows:

$$Q = aP^b \qquad (1)$$

where Q = the quantity of water demanded; P = the price of water per kl; a = a constant; and b = the price elasticity coefficient. Differentiating Q with respect to P in equation (1) gives

$$\frac{dQ}{dP} = abP^{b-1} = b\frac{Q}{P} \qquad (2)$$

$$\text{Thus, } b = \frac{dQ}{Q} \div \frac{dP}{P} \qquad (3)$$

$$= \frac{\text{\% change in quantity demanded}}{\text{\% change in price of water}}$$

The price elasticity coefficient, b, is the measure of the sensitivity of water use to price changes and is always negative. Since different groups or classes of water users respond differently to price changes, different values for b must be used to predict how price changes will affect the average daily demands of specific user groups. Table I summarizes

TABLE I

Price Elasticity Of Demand Estimates

Investigator (s)	Ref.	Price Elasticity (b)	Comments * +
Bain *et al.*, (1966)	7	-1.099	41 waterworks systems in California, U.S.A. cross-sectional.
Clark and Coddard (1977)	-	-0.63	22 waterworks systems in Cincinnati, Ohio, U.S.A.; cross-sectional.
Conley (1967)	8	-1.02 to -1.09	24 waterworks systems in southern California, U.S.A.; cross-sectional.
DeRooy (1974)	9	-0.354 to -0.894	30 waterworks systems, industrial users, U.S.A.; cross-sectional.
Elliott and Seagraves (1972)	10	-0.70	33 U.S.A. cities, industrial users; cross-sectional.
Ethridge (1970)	11	-0.40	5 poultry dressing plants, U.S.A.; pooled time series, cross-sectional.
Flack (1965)	12	-0.12 to -1.0	54 waterworks systems in western U.S.A.; cross-sectional.
Fourt (1958)	13	-0.39	34 waterworks systems, U.S.A.; cross-sectional
Gallagher and Robinson (1977)	14	-0.24 to -0.894	14 households, residential in-house, Australia; cross-sectional.
Gardner and Schick (1964)	15	-0.77	43 waterworks systems in Utah, U.S.A.;cross-sectional.
Gottlieb (1963)	16	-0.66 to -1.24	waterworks systems in Kansas, U.S.A.;cross-sectional.
Grima (1972)	17	-0.93	91 waterworks systems, U.S.A.; cross-sectional.
Hanke (1970)	18	-0.59	Boulder, Colorado, U.S.A., residential in-house use; time-series (1955-1968).
		-1.39	Boulder, Colorado, U.S.A., residential outdoor use; time-series (1955-1968).
Herrington (1972)	19	-1.16 to -1.58	Industrial water use in England and Wales; cross-sectional.

TABLE 1 (Continued)

Investigator (s)	Ref.	Price Elasticity (b)	Comments * +
Howe and Linaweaver (1967)	2	-0.703	10 waterworks systems in western U.S.A., residential outdoor use; cross-sectional.
		-1.57	11 waterworks systems in eastern U.S.A., residential outdoor use; cross-sectional.
		-0.231	21 waterworks systems in U.S.A., residential in-house use; cross-sectional.
Metcalf (1962)	20	-0.65	29 waterworks systems, U.S.A., cross-sectional.
Morgan (1973)	21	-0.25 to -0.45	water supply systems in southern California, U.S.A., residential use; cross-sectional.
Rees (1969)	22	-0.958 to -6.71	Industrial water use in England; cross-sectional.
Renshaw (1958)	23	-0.45	36 waterworks systems, U.S.A., cross-sectional.
Ridge (1972)	24	-0.30 to 0.60	Brewing and fluid milk plants, U.S.A.; cross-sectional.
Seidal and Bauman (1957)	25	-0.12 to -1.0	water works systems, U.S.A.; cross-sectional.
Turnovsky (1969)	26	-0.05 to -0.4	19 waterworks systems in Massachusetts, U.S.A.; cross-sectional.
Ware and North (1967)	27	-0.61 to -0.67	waterworks systems in Georgia, U.S.A.; cross-sectional.
Wong *et al* (1963)	29	-0.01 to -0.72	waterworks systems in Illinois, U.S.A.; cross-sectional.
Wong (1972)	28	-0.02 to -0.28	Chicago, Illinois, U.S.A.; time-series (1951-1961).
Young (1973)	30	-0.41 to -0.60	Tucson, Arizona, U.S.A.; time-series (1946-64).

* Cross-sectional represents a study in which data are taken as one point in time from several locations.

\+ Time-series represents a study in which data are taken from one location over several time periods.

representative elasticities for various user groups.

Looking, for example, at the coefficients derived by Howe and Linaweaver (2), we see that residential in-house use responds little to price changes: a one per cent increase in price decreases average daily water use only slightly more than two-tenths of one per cent. Outdoor water consumption is a different story: a one per cent increase in price reduces use by nearly one and six-tenths per cent in the relatively humid eastern United States and about seven-tenths per cent in the drier western part of the country.

To design treatment plants, service reservoirs, trunk mains, and reticulation, we should also know both the peak demands in the system and how changes in price affect the peak demands. Howe and Linaweaver (2) provide, however, the only reliable estimates of peak demand elasticities - elasticities considerably smaller than average daily ones. Increases in price, then, diminish the total quantity of water used during a billing period but apparently do not appreciably curtail peak demands.

Tariffs

Using price-demand relationships in combining engineering and economics requires an understanding of water tariffs. The *level* of tariffs depends on how much revenue water authorities need: and how much is needed depends on the mix of, among other things, past investments, depreciation policies, current operating costs, and the degree to which the authorities are self-financing.

Revenue sources are revealed in the *structure* of tariffs, which generally comprise the following elements:

1. commodity charges (prices) which are derived from any method of charging according to the amount of water used;

2. periodic fixed charges which are levied either on top of or instead of commodity charges; and

3. other charges such as property taxes (rates), benefit assessments, connection charges, and developer contributions.

Most countries use some combination of all these elements. In England and Wales, for example, industrial customers usually pay commodity charges, rates, and other charges unrelated to how much water they consume. Commercial and domestic customers typically pay only rates and other non-volumetric charges. Most other industrial countries, however, rely more heavily on commodity charges.

In England and Wales, integrated engineering and economic planning are not ruled out because commodity charges are not heavily relied upon for industrial customers do pay commodity charges, thus admitting price elasticities and the integrated planning that means little without them. Furthermore, the English and the Welsh will likely call more and more for integrated planning as they increasingly come to see the benefits of commodity charges, i.e. metering; and the benefits of metering are enhanced through that very planning. Again, these benefits include the following.

1. As the real cost of developing new supplies increases, the savings from reducing consumption by metering will increase.

2. Only by charging per unit prices for water can authorities eliminate cross-subsidies between consumers. (The Water Act of 1973 calls for eliminating cross-subsidies by 1981.)

3. Because planners can forecast water use more reliably if customers are metered, they can thus reduce the large and expensive safety margins currently included in water systems. (3)

4. Only by metering and by charging commodity charges can water authorities tell how much their customers value urban water. This information is valuable and not properly considered by those who make metering decisions.

Here we shall deal with only those tariffs in which prices are set equal to marginal costs and are, therefore, not affected by changes in the revenue needed by an authority. Hence, issues related to revenue requirements are not dealt with, since they do not affect prices and the quantity of water demanded.

Calculating Marginal Costs

Although a large amount of literature deals with calculating marginal costs, the discussions are scattered in a jumble of published and unpublished documents (see ref. 4) for a clear review of the most commonly used marginal cost conceptions), are mostly theoretical, i.e written by economists for economists, and are not especially directed to the water supply industry. Nevertheless, we can here say something about marginal cost pricing of water.

We begin by dividing the capital expenditure programme for the planning period under consideration into that part related to the amount of water demanded and that part not related to water demands. The first part includes not only the costs of the physical works but also any environmental costs associated with developing the works. As consumers use more water, they will require more capital and more environmental resources. Unlike the "out of pocket" costs of projects, environmental costs are usually "opportunity" costs that reflect the value of the environmental benefits which have been foregone. Even though water authorities may not have to compensate those who would have benefited from some alternative use of the environment, they should include these foregone benefits as costs. In short, if the price that consumers face is to reflect the value of the resources required to supply more water, the calculations must include the "out of pocket" and the environmental costs of source works, trunk mains, treatment plants, and service reservoirs. This price, the only element of the tariff that directly affects the volume of water used, is the only element of the tariff we need in order to integrate engineering and economics.

The second part of the capital expenditure programme consists of the costs of distribution mains, reticulation networks,meters, services, and annual provisions. Because these costs depend on the number of customers served and not directly on the volume of water used, we should not include them in our calculations of marginal water costs. Therefore, these costs are not part of the commodity charge (water price). They may be appropriately accounted for by using other elements of a tariff structure, e.g. periodic fixed charges, connection charges, and developers' contributions. Since these charges do not directly affect water use, we will not consider them further in this discussion (see ref. 5 for a full treatment of this topic).

To compute the marginal costs of water (generally the costs of supplying more water to the reticulation system), we need to know for each year in the planning period the estimated increment in water use and the increment in investment (the cost of works and the environmental costs) planned to meet the increased use. Because investment increments often change abruptly from year to year, we will find it useful to average the marginal costs of water over some years - thus smoothing the marginal cost curve (see refs. 5 and 6 for examples). Here, I shall average over five years. Therefore, in a given year, marginal capital costs are defined as the annuitized value of the investments that are planned for the following five years, divided by the increment in total water use for those five years.

We may express this definition as follows:

$$\text{Marginal Capital Costs}_t = \frac{1}{5} \frac{\sum_{j=t}^{j=t+4} r I_j}{\Delta Q_j} \qquad (4)$$

Where I_j = the total capital investment that becomes operational in a given year j, with capital expenditures made before the year of operation being discounted forward to the year j at i, the rate of interest; r = the capital recovery factor, and this is the annual payment that would repay a unit loan over the economic life, n years, of the investment with compound interest at i on the unpaid balance, i.e.

$$r = \frac{i\,(1+i)^n}{(1+i)^n - 1}$$

Since the parts of a capital programme have different economic life spans, different values of n and, therefore, r must be used for the various parts of the programme; and ΔQ_j = the increment in annual demand for year j, i.e. $Q_j - Q_{j-1}$.

For convenience, we define marginal costs for a given year, since capital expenditure programmes usually assign investments to specific years, and, for the investment programme as a whole, plan for a specific demand level for each year. When marginal costs are to be used to set prices for the coming year, however, we use the expected demand level to determine the marginal costs, regardless of when that particular level appears in the original planning model. In other words, when setting prices, we should treat marginal costs as a function of expected demand levels, and not of time.

It is sometimes desirable to refine the calculation of marginal costs by dividing the total capital expenditure into: "off-peak" capital, i.e. that expenditure needed to meet increments in annual demand at a rate not exceeding the average demand rate, e.g. the average daily demand of the system as a whole; and "peak" capital, i.e. that expenditure needed to meet increments in annual demand at a rate exceeding the average demand rate. When summer water use is considerably higher than winter use, the marginal capital costs of providing water during the summer exceed those during the winter. If consumers are to be given signals that reflect the value of resources used to provide them with water, summer prices should equal off-peak plus peak marginal costs, and winter prices only off-peak marginal costs.

Because source works are typically designed to increase the overall yield of the system, we include their costs in off-peak capital. Trunk mains, treatment plants, and service reservoirs, however, are often designed to meet peak flow rates: therefore, we should include their costs in peak capital expenditures. Of course, just how much of various costs we assign to either of these categories depends on local conditions and design practices.

Equations (5) and (6) define the marginal off-peak and the marginal peak capital costs.

Marginal Off-Peak Capital Costs

$$t = \frac{1}{5} \sum_{j=t}^{j=t+4} \frac{r\, I'_j}{\Delta Q_j} \qquad (5)$$

Marginal Peak Capital Costs

$$t = \frac{1}{5} \sum_{j=t}^{j=t+4} \frac{r\, I''_j}{\Delta Q_{sj}} \qquad (6)$$

where I'_j and I''_j = the total off-peak and the total peak capital investments that become operational in a given year j; $I_j = I'_j + I''_j$ (see equation (4)); r = the capital recovery factor: ΔQ_j = the increment in annual demand for year j, i.e. $Q_j - Q_{j-1}$; and ΔQ_{sj} = the increment in summer demand for year j, i.e. $Q_{sj} - Q_{s\,(j-1)}$.

Like capital costs, operating and maintenance costs can be divided into those related to the quantity of water demanded and those not related to use. When setting prices, we are concerned only with the former. Since marginal operating and maintenance costs generally vary little from season to season, we need not break down the annual costs into peak and off-peak costs. Again, to even out abrupt changes that occur when planned investments become operational and thus need maintaining, we average the marginal operating and maintenance costs over five years. Thus,

$$\text{Marginal O + M Costs}_t = \frac{1}{5} \sum_{j=t}^{j=t+4} \frac{\Delta R_j}{\Delta Q_j} \qquad (7)$$

where ΔR_j = the increment in operating and maintenance expenditures for year j, i.e. $R_j - R_{j-1}$; and ΔQ_j = the increment in annual demand for year j, i.e. $Q_j - Q_{j-1}$.

Prices, then should be set equal to the sum of the relevant marginal costs, i.e. the capital plus the operating and maintenance marginal costs defined by equations (4) - (7) .

It may happen, however, that prices computed this way are too high and result in "excess" capacity, i.e. probable supplies that exceed probable demands: but we know that marginal cost pricing presupposes demands matching supplies. The apparent inconsistency clears up when we see that water authorities invested too much capital in such systems not long before they adopted marginal cost pricing. Therefore, since new capital is not required for some time planners for these systems should not at the outset include the total marginal capital costs in their price-setting computations.

When planners are faced with initial system capacities that are not "proper", capacities that are too large, they should set price just high enough to ration probable supplies. When this price reaches the relevant

marginal costs calculated from equations (4) - (7), authorities should invest in capacity and set future prices equal to the total marginal costs.

Predicting Water Use

Equation (1), the price-demand relationship, is the basic equation of integrated engineering and economic planning. To predict water use, however, we also need to know how variables other than price, i.e. variable such as population, standard of living, and land use patterns, affect water use. In our simple model we can accommodate these other variables in one equation:

$$Q = rQ_1 \qquad (8)$$

where Q is the water requirements in year two; r is the growth rate in the base demand from year one to year two; and Q_1 is the demand in year one.

Equation (8), then, represents the growth in demand when the real price is held constant from year one to year two. (In more sophisticated integrated planning models, the components of r are separately estimated. Here, though, since we are concerned mostly with the price-demand relationship that links engineering and economics, we combine those variables, other than price, that affect water use in one equation.)

Now, if price is increased from P_1 in year one to P_2 in year two and all other variables are held constant, we see from equation (1) that

$$Q_2 = Q\left(\frac{P_2}{P_1}\right)^b \qquad (9)$$

where Q_2 is the water demands in year two.

SUMMARY AND CONCLUSION

Fig. 1 schematically outlines integrated engineering and economic planning. We need to know the following for the method to work:

1. initial water demand, i.e. the demand projected for the start of the model (we may break the demand down into those of user groups within which we expect similar responses to price changes);

2. initial price, i.e. the price per kl. in effect while the initial water demand is made;

3. projected base growth rate i.e. the rate, r, that indicates the growth (or decline) in water use when real prices are held constant;

4. marginal cost curve, i.e. the curve computed by appropriately using equations (4) - (7); and

5. price elasticities, i.e. the price-demand relationships found in the service area under study or estimated from those of similar service areas (see Table I).

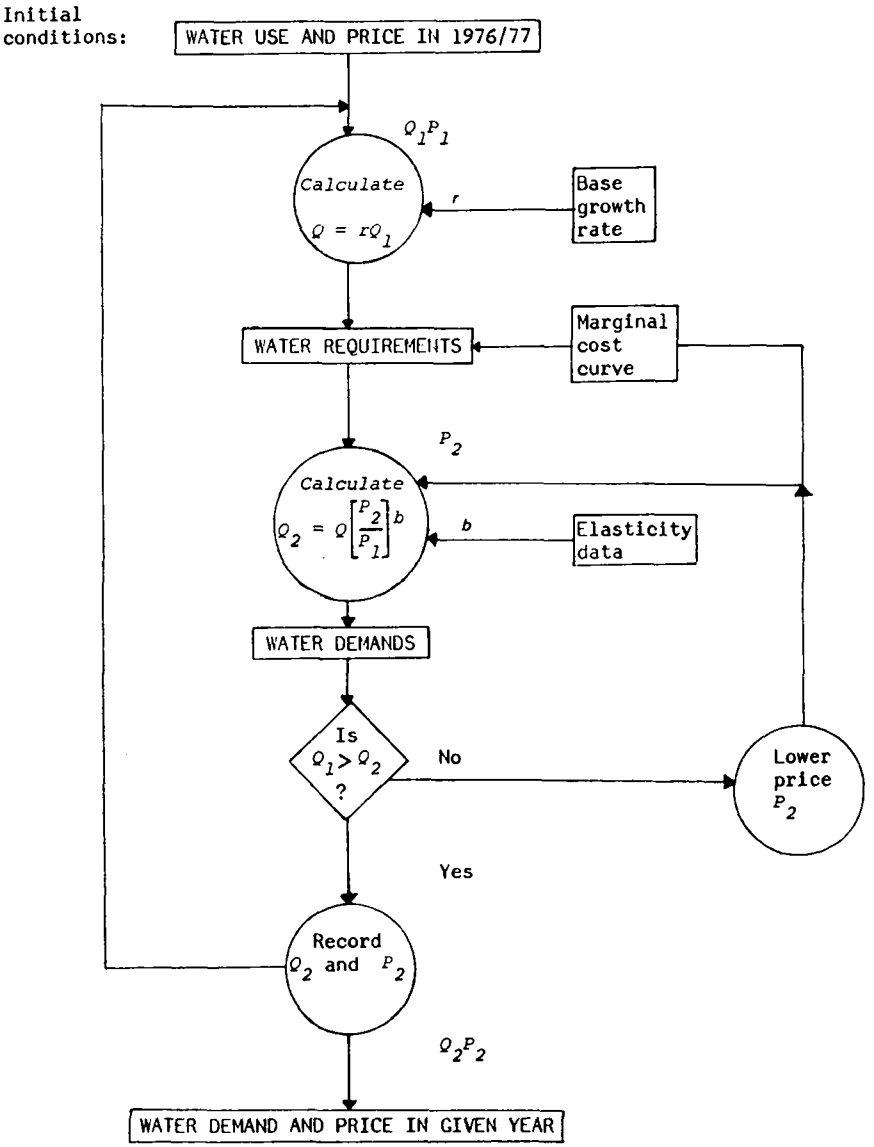

Fig. 1 Schematic outline of integrated engineering and economic planning

Integrating engineering and economics allows managers to use the price system to balance supplies and demands. In its more complex forms (not presented here), the method enables water authorities to evaluate better non-pricing rationing options, such as water use restrictions; building and appliance codes that affect water use; zoning regulations that by affecting land use, change water use; engineering standards, e.g. pressure, that affect water use and system costs; and so on.

Only by accommodating such a wide range of inter-related economic and engineering policies can the water industry move confidently into the 1980's.

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REFERENCES

1. Saunders, R.J. and Warford, J.J. 1977, Village water supply. The Johns Hopkins University Press, Baltimore, U.S.A.
2. Howe, C.W. and F.P. Linaweaver 1967, *Water Resources Research*, 1st qr., The impact of price on residential water demand and its relation to system design and price structure.
3. Kamen, C.S. and Dar, P. 1973, Factors affecting domestic water comsumption. Tahal-Water Planning for Israel Ltd., Tel Aviv.
4. Saunders, R.J., Warford, J.J., and Mann, P.C. 1977, Alternative concepts of marginal cost for public utility pricing: problems and application in the water supply sector (World Bank staff working paper no. 259). The World Bank, Washington D.C., U.S.A.
5. Binnie International (Australia) Pty. Ltd., Maunsell and Partners Pty.Ltd., Gilliland, E.J., Hanke, S.H. and Townsing, K.J. 1977, A preliminary development study. Perth M.W.S. and L.D. Board, Perth, Australia.
6. Hanke, S.H. 1976, An examination of alternative tarriff policies for the Engineering and Water Supply Department, Adelaide. E. and W.S. Dept., Adelaide, Australia.
7. Bain, J.S., Caves, R.E. and Margolis, J.S. 1966, Northern California's water industry. The Johns Hopkins University Press, Baltimore, U.S.A.
8. Conley, B.C. 1967, *Annuals of Regional Sci.*, Price elasticity of demand for water in Southern California.
9. DeRooy, J. 1974,*Water Resources Research*, Price responsiveness of the industrial demand for water.
10. Elliott, R.D. and Seagraves, J.A. 1972, The effects of sewer surcharges on the level of industrial water and the use of water by industry. Water Resources Research Institute, Raleigh, U.S.A.
11. Ethridge, D.E. 1970, An economic study of the effect of municipal sewer surcharges on industrial water. Water Resources Research Institute, Raleigh, U.S.A.
12. Flack, J.E. 1965, Water rights transfers - an engineering approach. Stanford University, Palo Alto, U.S.A.
13. Fourt, L. 1958 (unpublished paper), Forecasting the urban residential demand for water. University of Chicago, U.S.A.
14. Gallagher, D.R. and Robinson, R.W. 1977, Influence of metering, pricing policies and incentives on water use efficiency (Australian Water Resources Council technical paper no. 19). Australian Government Publishing Service, Canberra, Australia.

15. Gardner, B.D. and Schick, S.H. 1964, Factors affecting consumption of urban household water in northern Utah (Bulletin No. 449). Agricultural Experiment Station, Logan, U.S.A.
16. Gottlieb, M. 1963, *Land Economics*, Urban domestic demand for water: a Kansas case study.
17. Grima, A.P. 1972, Residential water demand: alternative choices for management. University of Toronto Research Publications, U.S.A.
18. Hanke, S.H. 1970, *Water Resources Research*, Demand for water under dynamic conditions.
19. Herrington, P.R. 1972, Regional cross-section analysis of public water supply consumption in England and Wales. University of Leicester.
20. Metcalf, L. 1926,*Jour. AWWA*, Effect of water rates and growth in population upon per capita consumption.
21. Morgan, W.D. 1973, *Water Resources Research*, Residential water demand: the case from micro data.
22. Rees, J.A. 1969, Industrial demand for water: a study of South East England (Research monograph no. 3). London School of Economics.
23. Renshaw, E.F. 1958 (unpublished paper), The demand for municipal water, University of Chicago, U.S.A.
24. Ridge, R. 1972, The impact of public water pricing policy on industrial demand and reuse. General Electric, Technical Information Series.
25. Seidel, H.F. and Baumon, E.R. 1953, *Jour. AWWA*, A statistical analysis of water works data for 1955.
26. Turnovsky, S.J. 1969, *Water Resources Research*, The demand for water: some empirical evidence on consumers' response to a commodity uncertain in supply.
27. Ware, J.E. and North, R.M. 1967, Price and consumption of water for residential use in Georgia. Bureau of Business and Economic Research, Georgia State College, Atlanta, U.S.A.
28. Wong, S.T. 1972, *Land Economics*, A model on municipal water demand: a case study of Northeastern Illinois.
29. Wong, S.T., Sheaffer, J.R. and Gotaas, H.B. 1963, Multivariate statistical analysis of water supplies. American Society of Engineers water research engineering conference.
30. Young, R.A. 1973, *Water Resources Research*, Price elasticity of demand for municipal water: a case study of Tucson, Arizona.

BIBLIOGRAPHY

Bauman, D., Dworkin, D. and Holtz, D. 1977, Municipal water systems: the challenge for urban resource management, "Pricing as a conservation tool - an economist dream come true?" by S.H. Hanke. Indiana University Press, Bloomington, U.S.A.

National Water Council 1976, Paying for water: a discussion of economic and financial policies for the water services. NWC, London.

DISCUSSION

Author's Introduction

PROFESSOR S.H. HANKE, in introducing his paper, said that engineering concepts had dominated planning in the urban water industry throughout the world. Engineering planning had served an essential role in determining the least costly methods of meeting projected water"requirements". However, engineering planning was limited in scope. It only focused on evaluating supply alternatives

to meet given water use "requirements".

Engineering planning had failed to account for the fact that the method of financing waterworks could affect the quantity of water demanded. Hence, water demands varied, depending on financing arrangements and other factors, and were not fixed "requirements".

Since both supplies and demands were variable, they must be treated as such when plans for urban water systems were made. Only by integrating engineering planning and economic planning, which included the method of financing works and its effect on water use, could supplies and demands be properly balanced.

The intention of this paper was to trace the broad outlines of an approach which had been successfully used to integrate engineering and economic planning.

Verbal Discussion

MR. M.J. ROUSE (Water Research Centre) said that some of his points would be relevant to Mr. P.R. Herrington's paper (p.6 1), but here he was concerned with the problems of introducing marginal costing in practice. There was the problem of deciding the size of the unit to which the costs should apply: should it be a district, should it be a division, or should it be a whole water authority? To a great extent this decision was constrained by equalization of charges considerations.

There was also a need to consider the time period. The author mentioned the need to avoid abrupt changes in charging and, in an example, considered a time period of five years. He suggested that this was too short a time and emphasized this point by referring to the economics of waste control. After all, waste was probably the largest single consumer and, although it had a good load factor, it had a negative ability to pay.

Marginal cost calculations carried out on waste control at the Water Research Centre showed that 20 times the number of waste control gangs could be justified before the introduction of major new sources, compared with immediately afterwards. Clearly this was impracticable - the labour gangs had to be set up and trained. So how far could a marginal cost approach be taken in practice? In connection with waste control policy, he preferred not to use a marginal cost approach, but to estimate all the future costs over a much longer period of time, say 20 or 30 years, and look for a minimum cost solution within practical operating constraints.

MR. P.T. MCINTOSH (Department of the Environment) said that both the author's paper and that by Mr. Herrington (p.6 1) were somewhat more theoretical than others presented at the Symposium. There was a need to hasten the development of practical procedures to fit in the gap between the more advanced concepts and current practice. For example, in the area of project appraisal the use of sophisticated choice and discounting techniques and benefit measurements must be accompanied by the use of a basic framework for project definition and selection. This would probably include taking an overall view on the constraints of resources, manpower, etc. in the context of a broad plan; setting up options for individual projects and more widespread plans which met the defined needs; including a consideration of the implications of no action being taken ; reliable cost estimates for both operation and capital; and finally identification of needs and priorities in some objective way. Some of the

points systems now in use or being developed were very useful for the way they were introducing systematic procedures, combining engineering and economic appraisals.

The concept of marginal pricing, as set out in the paper, was very important: but its potential impact on demand should not be overplayed in the UK where the water industry was essentially in the position of a monopoly, where it raised its revenue to a large extent from rate-based charges, and where price elasticities were,in many cases, thought to be low. Pricing rules would not be likely to have a large impact on many major elements of demand in the next, say, 10 years.

However, improved costing of the elements of demand and the implied incremental prices were fundamental inputs to the relationship between resources, planning, and finance. Reliable overall and unit cost estimates, at least on a current cost accounting basis, and probably on a forward-looking basis, were vital for many reasons, e.g.for direct use in charges for those consumers where the price message had a significant impact (maybe, for example, metered water users, trade effluent charges, and for connection charges); to allow authorities to plan and take decisions on behalf of the community in those areas where the action was not signalled by consumer response; to derive broad splits of the cost responsibility between consumer groups; and to permit financial planning to meet present commitments and future financial and resource needs.

Author's Reply to Discussion

PROFESSOR S.H. HANKE said that the task of replying to the discussion had been made relatively easy, since he fundamentally agreed with the thrust of the comments and questions. Therefore, he continued by amplifying the comments.

Mr. Balmer had noted (see discussion on paper 6, p. 6 23) that reductions in water use, resulting from increases in per unit real prices of water, were sluggish, i.e. that short term effects of price increases were less than the long term effects. This observation was correct and had been verified: it should be incorporated into integrated planning efforts.

Short run price elasticities for water were less than long run elasticities for two reasons. Firstly, information took some time to be effectively transmitted to consumers. It took several bills with a new price before consumers fully realized the implications of their water-use patterns. It was only after consumers realized these implications that they could adjust their water use to the new prices. Secondly, and more importantly, water use was largely determined by the stock of water-using equipment that consumers possessed. Hence, the full effect of a price increase was realized only after the current stock of equipment was replaced. However, unless water price increases were large and/or the cost of water was a significant portion of a consumer's budget, replacement of existing equipment with water-saving equipment was economical when the current stock wore out or became obsolete. Adjustments in the stock of water-using equipment to higher water prices, therefore, took some time.

Mr. McIntosh (see also Mr. P.R. Herrington's reply, p.6 31) correctly pointed to the need to develop practical procedures which would fill in the gap between the more advanced concepts suggested in the Symposium and current practice. At present, there was a considerable amount of literature which was addressed to the more advanced concepts of planning for and financing of urban water authorities. However, it was:

1. scattered in a jumble of published and unpublished documents;

2. mostly theoretical; and

3. typically written by economists for economists.

What was needed was a handbook which translated theory and concepts into practical procedures that could be readily employed by practitioners. At the time of writing, he was aware of only one project which had as its objective the development of such a handbook. Mr. Warford, Mr. Saunders and the author were in the process of preparing a practitioners' handbook for the World Bank. Hopefully, this book would assist practitioners in the application of more advanced economic concepts.

For those who were interested in a more detailed treatment of the concepts presented in the paper, he referred to the Binnie International Pty. Ltd. report which was cited in the paper and reported on at the Symposium by Mr. J. S. Hetherington (see discussion on paper 6, p.6 24). Perhaps this report reflected the most comprehensive application of more advanced concepts to urban water planning problems.

Mr. McIntosh made two additional remarks which were related to his first point. On the one hand, he hypothesized that the impact of marginal cost pricing would be small in the UK, while on the other hand, he stated that there were advantages to be realized in the planning process by switching to a marginal approach to costing and by integrating engineering and economic planning. He concurred with this assessment of the potential advantages to be derived from altering current planning procedures so that marginal costing was used in integrating engineering and economic planning. It was only by employing this approach to planning that the potential savings that could be derived by switching from current tarriff structures to marginal cost pricing structures would be known quantitatively. The quantification of these potential savings for individual authorities, or parts of them, in the UK was an empirical matter that had not been properly studied. For a guide to how these empirical matters could be settled, he again referred to the report by Binnie International Pty. Ltd. *et al.*

Mr. Rouse raised several important points concerning the introduction of marginal costing and pricing. He dealt with Mr. Rouse's first question about geographic units for computing marginal costs in a rather straightforward way, at least from a theoretical point of view. The marginal costs of yield delivered to any water system varied, depending on the source of the yield. Moreover, the marginal costs of distribution and reticulation varied, depending on the density of the service area and the distance of any consumer from the system's load centre. In principle, these cost variations should be reflected in the tariffs faced by each consumer. However, tariffs that were tailor-made for each customer would be costly to produce and administer. Therefore, tariff zones in which a single tariff was applied to all customers within the zone should be introduced. The size of the zones should be such that the marginal costs of providing service within each zone were "reasonably" uniform, i.e. the size of each zone should be extended to the point where the benefits, in terms of increased pricing efficiency, were equal to the costs of computing and administering the zoned prices. By following this guide, prices would not greatly diverge from marginal costs, and cross-subsidies and pricing inefficiencies would be small. This implied that the zones would be smaller than the service areas of existing water authorities in England and Wales. The political implications of such zones would, of course, have to be considered in the final determination of zone sizes. However, this did not imply that the

benefits and costs of zoned tariffs should not be computed.

Mr. Rouse correctly pointed out that an objective of a tariff should be stability, i.e. water prices should not fluctuate and/or abruptly change. Stability could be achieved by phasing-in new tariff structures, such as marginal cost structures. It could also be achieved by using longer rather than shorter time horizons to compute marginal capital costs once marginal cost pricing had been adopted. For example, he had suggested in the paper that a five-year moving average method be used for purposes of "smoothing" marginal cost curves. The length of time chosen would depend on the nature of the capital programme in each water authority and its preferences for price stability.

6. CHOICES WITHIN THE WATER INDUSTRY : DOES ECONOMICS HELP?

P.R. Herrington, BA, MSc*

INTRODUCTION

An economist daring to pose this question within the Institution ten years ago would presumably have been dismissed as a crank if anything more than the most economic of one-word answers had been attempted. The guest would probably have been despatched back to an ivory tower, and diplomatically advised to steer out of water and concentrate his or her undoubted talents in a more appropriate area for economic analysis, such as attempting to devise policies for curing the United Kingdom current payments account deficit. Success in this area might have moved the economy marginally away from stop/go towards go/go: a macroeconomic transformation that would have facilitated even more of the new water supply schemes which were in the 1950s and 1960s too often planned and executed without any rigorous justification.

Today the economic world in which water professionals must swim or sink has changed beyond recognition. From stop/go we have moved to stop/get ready/forget it/stop. Rigid Treasury limits constrain Regional Water Authority (RWA) capital expenditures, and the 1974 reorganisation, recognising the often acute interdependence of the major water services, has ensured that these services compete directly for limited resources. Charges have increased rapidly as subsidies and stone age accounting systems have been jettisoned and attempts are made to even out standards of service by pulling up rather than pushing down.

Consequently two areas now appear to dominate the industry's managerial thinking: investment appraisal and the establishment of sensible and fair charging policies. It is the purpose of this paper to investigate the role of economics in the first of these, 'investment' being granted a broad interpretation, and it will be concluded that economic analysis does provide assistance, both in clarifying the principles involved in choosing between alternatives and also in helping to resolve choices in 'real' situations. Indeed, it may be argued that the water services comprise one field of enquiry where the application of small doses of economics may still give rise to high marginal returns.

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The water services in the United Kingdom have a politically determined annual capital investment programme of over £600m. (1975 prices), some 8% of total public sector investment. By any standards these are large figures; they reflect, both directly and through the implied need for other inputs for operating purposes, the use of significant proportions of the economy's scarce resources. It is thus desirable that the selection of new capital projects and other means of reconciling the future demands and supplies of the nation's water services be undertaken in a rational and dispassionate framework rather than on the basis of hunch, guesswork, rule of thumb, or horse trading.

FINANCIAL AND ECONOMIC APPRAISAL

An economic investment may be generally characterised by the accumulation of benefits to consumers as a result of an initial commitment and continuing use of economic resources. Appraisal means somehow weighing up the benefits against tying-up resources. The two sides of the balance-sheet are not as disparate as may appear, for resource use is evidently an economic cost, and cost in economics means opportunity cost: the value placed on resources in their best alternative employment. Consequently resource use is equivalent to rejected benefits. Costs are negative benefits.

A less comprehensive but more common variant of appraisal in the public sector compares the relative merits of mutually exclusive projects each designed to provide a given array of benefits (e.g., additional public water supplies at a predetermined rate). In such cases the assessment of benefits is often ignored and that project making the least onerous overall demand upon resources will be favoured if economic criteria are paramount in the selection procedure.

We must now recognise a fundamental distinction, sometimes glossed over in the project appraisal literature: between financial appraisal and economic appraisal (Hirshleifer et al (1)).

Financial Appraisal

This is the rational method of assessing an investment project for any enterprise aiming for some version of profit maximisation. Regard is paid not to the value of the generated benefits as perceived by consumers or society as a whole (social benefits) but to the appropriation of those benefits in the form of sales and therefore cash received (private benefits). Similarly the cost of a project to a firm is the compensation or reward that must be paid for resource use plus net transfer outpayments (private costs) rather than an evaluation of overall resource use less any reduction in other economic units' welfare caused by the project (social costs).

The common denominator of private costs and benefits is £s, and financial appraisal boils down to comparing streams of cash inflows and outflows over time. Discounting permits inter-temporal comparisons (see below) and the resulting Discounted Cash Flow technique is widely used in private industry. Being an assessment of the financial profitability of spending a sum of money in a certain way, financial appraisal is, or should be, at root a private sector activity. Its use in the public sector should be restricted to situations where the agency has a specific remit to select only financially viable projects or where it is known or can be shown to be a good surrogate for economic appraisal.

Economic Appraisal

In distinction, a 'pure' economic appraisal is basically indifferent to cash flow. It is concerned to identify, evaluate and compare the social benefits and social costs of an investment project. Thus the value of a resource in terms of the forgone benefit, and when it is committed, enter the balance-sheet on the negative side, and these may be quite distinct from the value and timing of any monetary compensation paid. A familiar example is the employment of people who would otherwise be unemployed; the economic cost in terms of forgone production is zero but the monetary costs to the employing agency are the wage and various employer contributions. Another example is that loan charges play no part in economic appraisal (because they do not represent the use of economic resources) but they are an integral part of a 'pure' financial appraisal based on cash flows.

Hence economic appraisal amounts to an assessment of the economic implications of utilising resources (especially real capital) in a particular manner. Since many public sector agencies, including RWAs, are charged with the pursuit of the public interest rather than a commercial one in their provision of goods and services, their analysis of the desirability of investment schemes should primarily take the form of economic appraisal, tempered as necessary by financial considerations (such as any obligation to break even). The common denominator of the balance-sheet will still be £s, with the emphasis, however, very much on the monetary evaluation of benefits accruing and resources used and not on cash flows. Economic appraisal is therefore not Discounted Cash Flow.

There admittedly remains much scope for debating how widely the net should be cast in searching for all the beneficiaries of and costs incurred by a project. The construction of a large water supply scheme like Kielder or Rutland Water may have significant and permanent effects on complementary economic activities in the region, and if these effects are technological rather than pecuniary - i.e. if they change the productivity of resources employed instead of just shifting wealth and income around - then they should be included as part of the analysis. It must probably remain largely a matter of judgement just when and where to halt the search for these effects (Walsh and Williams (2)).

Social Appraisal

For very large projects, like those mentioned and multi-purpose estuarial schemes, it is useful to distinguish a third and even more all-embracing level of feasibility study: a social appraisal, to include consideration of both the broader social and environmental impacts which might ensue and also, because of the size of the capital resource committed, the alternative methods by which the region or nation could hope to gain the benefits being sought or otherwise to resolve the supply shortages presumably being anticipated. It would not normally be possible or desirable for a RWA to undertake such an appraisal itself.

Discounting

One of the less elegant answers to the question 'Why discount?' was offered by Her Majesty's Treasury a few years ago: "Jam today is worth more than jam tomorrow." (3). Although discounting techniques are now widely accepted in the water industry, it is still possible to detect doubts concerning the principle behind the jam proposition, mainly because of the lack of concern about the future use of resources (especially energy and certain raw materials) that seems to be implied. Examined closely, this conservationist argument amounts to the claim either that the discount rate should be zero (or perhaps even negative) or that the economic costs of particular inputs will rise in real terms in future years. Consideration is therefore deferred to succeeding sections and the appendix.

Being now so well established [by, e.g. Rees (4)], the mechanics of the use of discounting require only a cursory mention here. In a situation where there are no overall constraints on project selection deriving from political, financial, or resource limitations, it is economically rational to go ahead with a scheme if the net present value (NPV) of all social benefits and costs is positive. Similarly, in a cost-effectiveness exercise the scheme with the lowest present worth (PW) of all social costs should be chosen. Introduction of an "effective" constraint, i.e. one that bites and is not purely academic, must alter the rule, however, since

(a) not all schemes with a positive NPV can now be selected, and

(b) it is obviously wrong to choose the "highest NPV" projects if they individually use up "too much" of the constrained factor (which might be, e.g. additional land-take, the overall capital budget, or the extra supplies available of certain categories of labour.

The correct selection rule becomes: evaluate for each scheme the ratio of the NPV to the number of units of the constraint used by that scheme, rank the projects in order with the highest-rate scheme at the top, and then work down the list choosing projects until the constraint is exhausted. Those chosen will then constitute the optimum set if the exhaustion is precise. In the analagous cost-effectiveness problem, however, minimizing the PW of costs per unit of constraint is not equivalent to maximizing the NPV per unit of constraint since the difference between the two (the PW of benefits per unit of constraint) will vary with each scheme: the benefits are of course the same but constraint utilization differs.

All this implicitly assumes that we need to make a choice for only one time period (e.g. the next year). Much more intricate problems arise if:

(i) the constraint is expected to continue to operate, perhaps at different levels, in future periods;

(ii) projects considered in the first period continue to make claims on the constrained factor in some succeeding periods;

(iii) projects are interdependent temporally (e.g. if 'A' is carried out now, 'B' will appear more attractive in three years' time);

and/or

(iv) different constraints (e.g. capital, labour) are expected to come into operation in different future periods.

Rigorous solutions may sometimes then be provided by mathematical programming techniques (e.g. Bromwich (5)), the output being the selection of an optimal set of investments stretching into the future, e.g. for the period of a medium-term plan, for which it may be plausible to estimate future constraints (capital allocations, charges ceilings, etc.)

Choice of Discount Rate

At what rate should expected costs and benefits in a given year be transformed into other-year (especially present-day) equivalents, so that like may be compared with like in appraisals? For private sector financial appraisal there is no problem; the appropriate rate is the firm's borrowing rate of interest since this determines the present exchange value of a future sum of money. In economic appraisal, however, the agency's (RWA's) borrowing rate is wholly irrelevant, since it tells us nothing about the present value to the community of a future stream of social benefits and resource commitments. Economists have instead concentrated on two possible rates for discounting in the public sector, the Social Opportunity Cost (SOC) and Social Time Preference (STP) rates, and these are explained in more detail in the appendix. The former reflects the fact that, again in the Treasury's words, "if we eat the seed-corn now we don't reap next year's larger harvest" (3), and this rate, expressing the cost to the community of carrying out a project in the public sector that displaces one in the private sector, has been institutionalised in the United Kingdom as the Test Discount Rate (TDR), at present 10% per annum.

STP relies on the argument that society, like most individuals, simply prefers jam today to jam tomorrow. The STP rate therefore expresses the community's view (or, some would claim, inevitably the government's view of the community's view) of the value of extra consumption benefits (and costs: negative benefits) in the future as compared to the present. Although impossible to observe and measure directly, STP rates have been estimated by various indirect

methods. The most recent investigation in the United Kingdom suggests a figure of 4.5% or 6.0%, the choice depending on the expected rate of growth of a defined 'base-level income' (see appendix). The range thereby generated is consistent with figures previously suggested for the United Kingdom and with Balmer's "equitable rate" of 5% recommended in 1975 for water industry use (6).

Inflation

Confusion is still encountered concerning the effects of inflation on discounting, and often this can be shown to arise from a failure to distinguish correctly between strict financial appraisal (the use of money) and economic appraisal (the use of resources). In financial appraisal either all flows should be forecast in nominal terms and the discount (borrowing) rate left that way or all the components of the analysis should be expressed in real terms. The same answers will materialise.

In economic appraisal, however, the ground rule for dealing with expected general inflation is remarkably simple: ignore it. For the discount rate, whether SOC- or STP-based, is expressed in real terms; and the actual money values which are expected to be attached to future social benefits and costs are mere veils, cloaking the far more important relative valuations which are usually assumed both to be embodied in the prices of some base year and to remain constant for the life of the project. Should any relative valuations not be expected to stay constant, then the real values of the resource or benefit stream affected must be adjusted by the differential level of inflation or deflation anticipated. In practice, expectations of differential inflation are usually held with less than complete certainty, in which case the question of how to allow for them becomes more complex.

Risk

Risk exists whenever the analyst does not know for sure the future or present value of a variable (benefit and cost flows, future differential inflation rates, etc.) but there is some information about the relevant probability distribution. In principle, there are three ways of trying to cope with the problem [Pearce (7)].

First, the bad method: add a 'risk premium' to the discount rate. Among the objections are the unjustified implications that risk increases temporally in an exponental fashion and that benefit and cost streams suffer from risks on the same scale, as well as the fact that there is no guide as to how large the premium should be. Second, the better method: incorporate the risks in the expected (mean) value of the variable(s), which has the advantage of restricting the analysis to point estimates and thus makes computational work easier. A typical problem arising with this method is that it makes no allowance for the possibility of a future benefit stream which is less than expected (e.g. a water supply

through drought) being granted a higher valuation (cost) than the gain arising from an equivalent excess over expectations (e.g. a supply surplus). In this sort of situation the appraisal should ideally be based on some notion of expected utility, which would amount to finding the 'certainty-equivalent' benefit stream.

If, as is likely, it proves difficult or impossible to establish the community's 'certainty-equivalent', then resort may be had to the third and most straightforward approach, sensitivity analysis, to show how NPVs and therefore project choice are affected by varying the assumptions concerning benefit streams, relative prices, etc. The danger here is that the resulting ranges of NPV may be so great as to give little practical help to the decision-taker.

ECONOMIC APPRAISAL OF WATER SERVICES

The principles of economic appraisal have now been outlined. How is and how should the practice be undertaken in the water industry? If we can find acceptable appraisal methods, it should be possible to reconcile the so-called engineering and scientific 'needs' for replacement and additional services (sensibly, these are increasingly referred to as 'demands') with (a) restricted capital resource budgets and/or (b) the increases in charges that RWA members and customers are prepared to sanction and to pay. Note that 'investment' must not be restricted to projects which augment or maintain supplies of services. Schemes to restrict or manage demands, through, for example, increased waste detection effort, metering programmes and legally obligatory changes in domestic or industrial water-use technology, must also be appraised, for these are in every sense economic investments, usually involving an initial and continuing commitment of resources.

Examples are currently found of three approaches to appraisal in the industry:

(i) A cost-effectiveness exercise, the benefits being taken as given. There is no formal assessment of the overall worth of the project. The valuation of benefits implied by the decision to proceed with one or other alternative is always interesting and sometimes alarming to those trained in economic disciplines.

(ii) A full cost-benefit analysis, with resource use and benefits being measured wherever possible in present-value money equivalents at some set of usually constant prices.

(iii) The use of a points rating system, attempting to assess the relative merits of competing schemes by the allocation of points according to benefits generated and, in some cases, costs incurred.

(i) and (ii) need a discount rate for application, and this, together with the practice of project selection in alternative financial environments, will be discussed first. The use of the three appraisal methods will then be examined in turn.

Discount Rates and Appraisal Rules

Current Water Authority Practice. By government request the TDR is now used for analysing virtually all public investment in the United Kingdom. It has been applied by regional and national water agencies for some years, the Water Resources Board being largely responsible for popularising the concept in the industry. Early examples of application, in cost-effectiveness problems, were contained in the Board's regional and national studies ((8), (9), (10)) and its economic comparison of various desalination techniques with conventional water resource alternatives (11). More recently the National Water Council has used the TDR in its cost-benefit analysis of universal domestic metering (12).

There are no examples of authorities using STP-based rates, although Balmer recommended what appeared to be a STP-derived rate of 5% as "reasonable for most water industry projects" in 1975 (6) and the Water Resources Board mistakenly used, in addition to the TDR, a Treasury 'financing rate' (then 6%) for resource allocation comparisons in its desalination assessment ((3), p.3; (11)). For all resource allocation questions, therefore, the government has consistently recommended a SOC rate, and certainly in the water industry it has been and continues to be used for both cost-benefit and cost-effectiveness analyses. How suitable is this procedure? The blunt answer must be that it is inappropriate and may be seriously misleading in the present circumstances, when an individual RWA's aggregate capital expenditure is determined not by the capital value of schemes which do or would pass the TDR test but rather either directly by political-administrative capital rationing or indirectly by charges constraints. Consider now these alternatives.

Project Selection and Capital Rationing. If, because of a proliferation of desirable projects, the RWA or the industry as a whole spends all its capital allocation (the implication being that the resultant charges are acceptable to RWA members and thus - in theory - to consumers), then the opportunity cost of any given use of capital funds is the other investment(s), subject to the same budget, which have to be dropped. Thus it is wrong to evaluate individual projects as though the opportunity cost were private sector investment. The correct discount rate to use is a STP rate, and there is a straightforward capital rationing problem. As explained earlier in the section on 'Discounting', the way to rank the competing projects and to compare mutually-exclusive schemes is by evaluating for each of them the ratio of the NPV to the capital cost.

Project Selection and Charges Constraints. The second case may be closer to reality at present in some regional water authorities, with reports arising of capital underspending precisely because of attempts to keep annual charge increases down. It might be argued that the result of the previous paragraph again holds, since the capital allocation is also pre-determined in this situation, albeit by a different set of factors. Unfortunately, this may not be the case, for the same constraint on the annual charge increases will be consistent with a number of different capital budgets if

(a) there is significant variation in the capital-intensity of the projects chosen, or
(b) different methods of financing a given capital budget are associated with different increases in charges.

Abstracting from (b), the potential for a non-predetermined budget is probably only significant in water supply, where the choice might be between establishing a programme based on high capital-intensity impounding reservoirs and one built around lower capital-intensity river abstraction or groundwater developments. The effects on annual water supply bills could be much the same but the claims on capital resources would be very different.

In these circumstances, it is still appropriate to use the STP rate to establish the NPV of the future benefit/cost streams, but

(a) it is the NPV per unit of water supply charge increase associated with the project which has to be measured and ranked, and
(b) the capital cost has to be adjusted in recognition of the fact that an alternative use of resources - normally private sector investment - is assumed to be displaced at the margin.

This point is spelt out at the end of the appendix (p.6 20). If, however, the capital underspending by a regional water authority is balanced by permitted increases in the capital budgets of either other regional water authorities or other public sector agencies, the opportunity cost of the *marginal project is again the public sector scheme*(s) that has to be dropped. A STP rate should be used for ranking and least-cost comparisons, but this time there will be no adjustment to capital cost.

Cost-Effectiveness*

When a prior decision has been made to make available a set of benefits (e.g. certain flood alleviation or a defined higher reliability of public water supplies), and there are alternative locational or technological methods of providing them, then we have already seen that it is appropriate on economic grounds to choose that scheme making the least overall demands upon resources. For each scheme, therefore, the opportunity costs of capital and future resource use should be identified and evaluated, and then brought together in a PW calculation, discounting at the STP rate in all situations. With no effective constraint limiting the investment programme, the scheme with the lowest PW of costs should be selected. If, however, a constraint is effective it is generally impossible to make an economically rational choice, properly taking account of the use of the constrained factor, without evaluating the flow of benefits.

**This section was extensively rewritten following the Symposium after a fundamental error had been pointed out. The author is most grateful to R. Banerji and G. Davies of the Southern Water Authority for their assistance.*

The Effect of Capital Rationing: An example. How the fact of capital rationing can influence cost-effectiveness decisions may be shown by building onto the cost-minimization exercise used by Balmer (6) and largely reproduced in Table I. The choice is between scheme 'A', an impounding reservoir with gravity supply, and 'B', downstream river abstraction which makes necessary additional treatment costs. 'A' has a high capital cost, but maintenance and replacement are the only variable resource costs, while 'B' has a low capital cost and high pumping, treatment, and maintenance and replacement costs.

TABLE 1 Cost-effectiveness decisions without capital rationing

	Capital cost, £m	Present worth of all costs, £m Discount rate, %					
		12	10	8	6	4	2
Scheme A	4.80	4.42	4.53	4.66	4.82	5.06	5.62
Scheme B	1.10	2.21	2.68	3.46	4.92	8.18	19.07
Preferred scheme		B	B	B	A	A	A

Note: the PWs of all costs could be less than the capital cost in Balmer's example because the capital cost was assumed to be borne in 1976, whereas PWs were taken to the base year 1975.

Balmer's data and solution are summarized in Table 1, where it is seen that the objective of minimizing the absolute PW of all costs gives different preferred schemes, depending on the discount rate chosen. In particular, if the Test Discount Rate of 10 per cent was used, the less capital-intensive scheme would be chosen.

The capital rationing case is more complex, for the largest contribution to the net benefits of the overall investment programme will come from the scheme with the highest ratio of NPV to capital. Generally, scheme choice then requires knowledge of the common benefit-stream. Table 2 shows the calculations for correct choice in two cases. First, annual benefits of £0.6m are assumed to be generated in perpetuity; these give the PWs of benefits shown for various discount rates. The NPV per £ of capital is the PW of benefits per £ of capital less the PW of costs per £ of capital (derived from Table 1). Scheme B is preferred for all discount rates, capital rationing thus reversing the decision for the three lower rates.

TABLE 2 Cost-effectiveness decisions with capital rationing

		Discount rate, %					
		12	10	8	6	4	2
PW of benefits (£m)		5.0	6.0	7.5	10.0	15.0	30.0
PW of benefits per £ of capital	A	1.04	1.25	1.56	2.08	3.13	6.25
	B	4.55	5.45	6.82	9.09	13.64	27.27
PW of costs per £ of capital	A	0.92	0.94	0.97	1.00	1.05	1.17
	B	2.01	2.43	3.15	4.47	7.43	17.34
NPV per £ of capital	A	0.12	0.31	0.59	1.08	2.08	5.08
	B	2.54	3.02	3.67	4.62	6.21	9.93
Preferred scheme		B	B	B	B	B	B
PW of benefits (£m)		3.0	3.6	4.5	6.0	9.0	18.0
PW of benefits per £ of capital	A	0.63	0.75	0.94	1.25	1.88	3.75
	B	2.73	3.27	4.09	5.45	8.18	16.36
PW of costs per £ of capital	A	0.92	0.94	0.97	1.00	1.05	1.17
	B	2.01	2.43	3.15	4.47	7.43	17.34
NPV per £ of capital	A	-ve	-ve	-ve	0.25	0.83	2.58
	B	0.72	0.84	0.94	0.98	0.75	-ve
Preferred scheme		B	B	B	B	A	A

In the second half of Table 2, we suppose that annual benefits are worth only £0.36m. Similar calculations show that for four discount rates, one of the schemes has a negative NPV, but in the two cases where there is a "sensible" choice, 'B' is preferred with the rate at 6 per cent and 'A' at 4 per cent. Thus with capital rationing, scheme choice depends on the size of the benefits as well as the discount rate. If, as is usual, the benefits are unknown, no general solution is available. However, individual cases may produce largely unambivalent results; thus in the above example, iteration shows that perpetual annual benefits of any amount greater than £0.6m always lead to 'B' being chosen for discount rates of 2 per cent to 12 per cent.

Economic Resources and Financial Costs. Throughout the paper we have stressed that investment decisions made in the public interest should have primary regard, on the cost side, to resource use and not to cash outflows. It is nevertheless true in many situations, particularly those involving small and medium sized projects offering minimal social and environmental disturbance, that the best practical guide to the value and timing of the resources used will be the estimated stream of financial costs (excluding loan charges, the sharing of existing overheads, and transfer payments not representing the appropriation of benefits). Thus many regional water authorities, in undertaking what they term a 'financial appraisal', are probably coming close to an economic appraisal. It is in the larger projects that estimated financial outflows may most obviously prove an inadequate guide; here, social and environmental costs, both temporary in the construction of a project (e.g. noise, dirt, disruption, congestion, accidents) and of a permanent variety (e.g. visual intrusion, irrevocable land-take), may well be important and will not usually be reflected in cash flows.

Intangibles. How to value such intangibles? There are three possible approaches. First, we could try to establish the compensation required by those who suffer the costs, for example by survey methods. But the 'publicness' of the costs experienced will generally prevent sensible answers to questionnaires. Second, evaluation may already be implicit in the market behaviour of economic units; thus land and property price differentials may, by careful study, be traced to the presence of certain intangibles, if we can be satisfied that other factors are constant, insignificant or already accounted for. Third, we may give up the attempt to value intangibles directly and instead rely on the implicit valuations placed on them by decision-takers in other situations. Hence it is comparatively easy to ascertain lower and upper limits to the value placed by the Water Resources Board on the social costs of land-take for reservoir construction, by examining with a toothcomb its preferred choices of supply programmes in the Northern and Wales and Midlands surveys (the raw data is in (8), Table H, and (9), Table M).

These are, of course, difficult areas, and they do not lend themselves to precise estimation. But that does not mean that it is economically rational not to devote any resources to their investigation. Certainly a plausible case can be made out for at least a preliminary investigation of non-private costs in schemes committing capital resources worth more than, say, ten million pounds.

Limitations. Finally, the limitations of cost-effectiveness must be realised. In the past world of single-purpose water agencies, the relevance of properly-conducted cost-effectiveness analyses would not have been questioned, granted that the initial decision to proceed with the provision of benefits was correct. Today's world is very different: reorganisation, unusual economic restraint and increasing supply costs have combined to make it often necessary for RWAs to compare (a) the benefits of the development of one water service with those of another and (b) the benefits of the development of a service to one standard or level of reliability rather than to another. It is to benefit estimation that we therefore now turn.

Cost-Benefit Analysis

Although the use of cost-benefit analysis in the industry has been very limited in Britain (I know of no such exercise for a proposed or actual extension in the supply of any of the major services), the previous paragraph suggested that increasingly benefits do and will have to be assessed, one way or another. The view taken by the author is that subjective evaluation of benefits will often produce erroneous, biassed and inconsistent choices. Additionally, some formalisation is required when RWAs and government are starting to spell out objectives in the water services with far more precision than hitherto.

Cost-benefit is one way forward, although in some other disciplines (notably transport) it has come under strong attack in recent years because of its inadequate handling of distributional questions (who gains? who loses?) and its seeming inability to cope with the environmental disturbances occasioned by project construction and operation. Neither of these difficulties appear to be so acute in the water industry. We will therefore now consider its possibilities.

The valuation problems on the costs side, discussed above, seem to pale into insignificance when we first confront the intricacies of benefit evaluation. What is the worth to the community of providing an enlarged supply of water or increasing the reliability of existing supplies? The initial reaction is: we have no idea. With no 'market' for domestic water, there is no sign of a market price with which we can begin to search for the value of benefits. It is obviously tempting to ask: how much would consumers be prepared to pay? Under certain conditions, which probably hold approximately for the water services, willingness-to-pay can be estimated by measuring areas under market demand curves. But in public water supply in Britain (and, indeed, even more in the demands for other water services), the almost total absence of empirical evidence with which we might simulate individual or community demand functions inhibits developments along these lines. In this apparently near-hopeless situation, is there any scope for cost-benefit? A number of techniques and developments suggest a positive answer, and these will now be examined. In outline they are:

(i) observe consumers' amelioration behaviour to generate implicit values of benefits;

(ii) estimate damage functions arising from non- or 'under-'provision of a service;

(iii) present consumers with a choice between a small number of different, clearly-defined standards of service which have costs and charges implications attached;

(iv) turn the problem on its head and conduct cost-benefit analyses of demand restriction and not supply extension.

Amelioration Behaviour. The idea here is that the value of the provision of a higher service standard may be inferred by measuring how much consumers spend to alleviate the bad effects deriving from the present 'inadequate' service. A little known but meticulously-researched study of the costs and benefits of improving the public water supply to a group of rural settlements in the West Midlands was carried out in 1968 by Tate (13), and this will now be summarised.

Four villages (domestic consumers and farms; population 900) took supplies directly or indirectly from a main aqueduct supplying a city. The two major drawbacks were (a) the aqueduct had to be shut down and dewatered three or four times a year (three days at a time) for inspection and repair and (b) because of topography three farms had poor pressure. The local water board proposed construction of a pumping station to raise water from the aqueduct to a new reservoir, giving storage capacity to cover shutdown and a gravity supply to improve pressures. No technically feasible alternatives were identified, so the economic question was: to go ahead or not?

Costs were estimated as the financial costs of resources purchased. No external costs were thought to be significant. On the benefits side, surveys of domestic consumers and farmers were undertaken to evaluate costs incurred (a) because of and during shutdowns and (b) because of low pressure. Confidence limits (99%) were calculated since the surveys were samples. Under (a), costs took the form of: the time taken and financial costs incurred to store and transport water; other inconvenience caused to householders; and technical impacts on farm production (such as loss of milk production) which the improvised measures did not remedy. Under (b) account was taken of expenditures on pumping systems to overcome pressure problems. All costs were converted to annual equivalents to produce a lower bound for the estimated benefits which would be derived from the improved supply.

As Tate recognised, all these costs must underestimate the actual benefits generated by the water supplied, for willingness-to-pay will have exceeded financial expenditures on improvisation. The results were nevertheless dramatic. On various assumptions concerning discount rates and assumed reservoir life, the new project was estimated to have a PW of costs between £53,000 and £60,000 (1968 prices), while the PWs of the identified benefit streams lay in the ranges £8,000-£29,000 (lower confidence limits) and £15,000-£38,000 (upper confidence limits). Tate concluded that on economic grounds the project should not be adopted (unsurprisingly, it had in fact been decided to proceed with it irrespective of the cost-benefit analysis).

The underestimates of benefits referred to, representing the consumers' surplus received by householders and farmers on the water they did choose to obtain, are potentially large, and Tate's conclusion may therefore be questioned. But a minor reformulation of the basic issue enables us neatly to sidestep that problem. We wish to compare the reservoir solution with a do-nothing (i.e. carry on as before) strategy. Thus we really need to compare the extra benefits of the project with its extra costs. The former are the resources and inconvenience saved (as correctly estimated by Tate) plus the value to be attached to the water which would be provided under the improved system but which consumers did not think it worthwhile to procure during the old system. This is the truly marginal demand for water, and the fact that resources were not devoted to its provision suggests it is of comparatively

low value. To measure the extra costs of the new project, we have to reduce Tate's estimated costs to allow for certain maintenance and replacement savings on existing connections, but these are minimal.

The result is that as an extra commitment of resources generating extra benefits the project would, in aggregate economic terms, have been wholly unjustified. It may be rejoined that such is too narrow a view, and that society may decide no community 'ought' to face shutdowns of the type specified. Certainly, society may decide to make such decisions; but it is the task of economists, and, I believe, of the water industry itself, to ascertain and publicise the economic implications of adopting general service standards of this nature.

Damage functions. A second method of coping with benefit evaluation is to make direct estimates of the physical damage (and its economic worth) which derive from the absence of or low quality standards in a service. This approach is most suitable for the appraisal of flood alleviation and pollution abatement schemes (see, for example, references (14) and (15)). In the case of flood alleviation, there are two stages in practice. First, an optimal return period needs to be established, probably at a regional or national level. In an unconstrained environment for project selection, this should be determined by ascertaining at which frequency of flood occurrence the marginal benefits from larger and 'safer' schemes begin to fall below the incremental costs of provision. Results may challenge time-honoured rules of thumb. Second, in a particular local situation, where it will probably be impractical to test different return periods, the economic question is whether the construction of a given scheme will have a PW of costs greater or less than the PW of estimated damage reduction. As before, capital rationing alters the rules for project acceptance.

Choices for Consumers. The third approach to benefit evaluation is also indirect; it presents alternative programmes direct to consumers or RWA members and lets them make decisions about standards and reliability of service in full knowledge of the implications of different choices for the capital programme and future charges. An example is provided by the manner in which Wessex WA recently chose the target dates by which it intended to achieve a defined reliability in public water supplies throughout its region.

The predetermined level of reliability chosen was expressed in the formulation that hosepipe restrictions were to be tolerated, given present demand forecasts, not more than an average of once in twenty years. Various packages, each containing (a) a target date for urban areas, (b) a target date for rural areas and (c) the implied capital cost per annum of reaching those targets, were put to a RWA working party including local authority members. Four options were presented in all, ranging from £5m. per annum (carry on as now, no targets

reached) to £11m. per annum (targets reached for all areas by 1983), and a combination costing £7m. annually and giving urban and rural areas the selected reliability level by 1986 and 1998 respectively was eventually selected.

Although a number of other factors contributed to the final choice, it is believed that the reliability/cost issue was foremost. By implication, then, deductions may be made to the effect that faster moves towards target dates were deemed to be worth less than the incremental costs involved (and the disbenefits of slower moves to be worth more than the cost savings generated). Faced with the absence of market prices and practical difficulties in indirect benefit evaluation, this approach of directly presenting consumers or their representatives with programme alternatives and the associated financial implications, particularly concerning broad choices within individual services, has many attractions. Is it too much to hope that before long consumers themselves may be presented with such choices concerning matters like reliability where rules of thumb often have no rational basis?

Demand Management. Finally, mention must be made of the enormous scope for cost-benefit analysis in assessing the economic viability of various suggested means of restricting the demand for water. Frequent references are made to proposals for increased detection and elimination of leakage (perhaps nearly a quarter of public water supplies), local domestic metering and enforced water-technology changes in the home: for example, dual-flush toilets, economy washing-machines, atomised heads on showers and taps, and limited domestic recycling systems, to be installed in all new installations and new dwellings. Metering and technology switches give rise to a stream of installation and maintenance costs which may be forecast with considerable accuracy and to a benefit flow mainly reflected in lower operating costs (small) and deferred capital costs (much more important) in water supply and sewage disposal systems. Although there is much more risk in placing values on the costs and benefits of future increased waste detection, in principle all these variants of demand management can be properly assessed in economic terms only through NPV techniques.

The cost-benefit theory of the domestic metering decision has been outlined at length by Warford (16) and Batchelor (17), and those who have grafted numbers onto the crucial parameters conclude that local domestic metering is economically viable either now [Rees (18)] or within the next decade [(17) and, implicitly, Smith (19)]. Earlier estimates of the impact effect of metering now look too high (18), with Jenking's Fylde evidence (20) suggesting a 14% reduction for 291 of the consumers who agreed to pay by unit quantity in the final year of the experiment, once allowance has been made for the general year-on-year growth in per household public water supplies in that area. The National Water Council exercise (12) was an attempt to assess universal domestic metering and was especially valuable for drawing attention to a number of benefits hitherto unquantified: the deferment of capital expenditure on (a) reinforcement of the distribution system, (b) reinforcement of

the sewerage system and (c) trunk sewers and sewage treatment. There is an urgent requirement for the National Water Council model of the problem to be applied at a regional level, using estimates of demand savings additional to the strangely ambitious 20% originally adopted.

Less work has been carried out on the costs and benefits of changing domestic water-use technology. In Britain the Building Research Establishment has been investigating all the changes listed earlier, and the scope for water savings has recently been discussed by Webster et al (21). Economic aspects are being examined but no results are yet publicly available.

Points Systems

For more traditional (supply) project appraisals, we have recognised the drawbacks in attempting to undertake cost-benefit analyses, particularly of small- and medium-sized schemes. And yet difficult decisions on the five-year capital allocations both within and between services will continue to involve such schemes. What else can be done? What are variously termed as Points or Priority Rating Systems are now or will soon be in use in at least three RWAs. These aim to reduce significantly or, in one case, virtually eliminate subjective evaluation in the choice of schemes. Instead a formal predetermined system of points is awarded for the size and type of benefits expected and, in two cases out of three, for estimated operating savings which will accrue.

The complexity of the systems varies greatly, from the extreme sophistication of Wessex WA ((22); possible entries in 868 different boxes) to South West WA's more straightforward 7-question, 27-possible-scores assessment (23). But all assemble a precise score, usually out of 100, for every project submitted for inclusion in the capital programme. The advantages of the method in reducing subjective error and bias are clear; the interesting question is whether in a points system these are simply replaced with objective error and bias. At least two fundamental problems arise.

Allocation of Points. First, how are points to be allocated in the first place? For example, how highly should public health improvements be rated in comparison with, say, water supplies for new housing not yet built or increased operating efficiency? At some early stage subjective evaluations will have been reflected in the points matrix adopted. But as the RWA's objectives shift in relation to changing circumstances and its developing perception of the region's problems, so, it is argued, the system can be accordingly amended.

Points for Costs? Second, the treatment of cost in the schemes is sometimes confusing. As soon as points are awarded, on a given scale, for a project's current cost savings or absolute costs, then benefits are implicitly being granted a monetary worth. It would be salutary to bring these worths out into the open (at present they are not). If, however, that is precisely what the Authorities wish to avoid, the difficult question

must be faced of how to incorporate costs into scheme-selection. The ranking of schemes by the ratio of benefit points to capital cost could be used to maximise gross benefits subject to a capital budget (capital rationing yet again!), but this will mean a wrong tendency to accept projects which are cheap to build and expensive to run.

To get round this problem two devices may be suggested. The PW of future operating costs could be added to capital costs so that the gross benefits of schemes are standardized by relating them to the PW of all costs. To this it may be rejoined that it is the capital budget, and not the PW of all costs, which is the effective constraint. In that case, since operating costs should not be omitted altogether they must somehow be subtracted from the benefits score. We are then back with the problem that operating costs must be given a points-equivalent, which means that benefits are implicitly accorded a unique monetary evaluation.

Conclusion. It is clear that points systems are useful devices, at the very least giving a formal consistency to some aspects of appraisal. The critic may reply: consistently in error! Perhaps so, but it is not at all obvious that these systems, if used sensibly and sensitively, are any worse than the alternatives currently available to the industry. For the multitude of smaller schemes for which cost-benefit analyses will normally not be worthwhile, a priority points system can provide at least a preliminary sifting mechanism and at most a final decision-taking device. It would seem important, however, to investigate further the problem areas specified above.

CONCLUSION

That terminates what may be viewed as a rapid and ambitious journey through and round the theoretical and practical problems of investment appraisal. The author's belief in the role of economics as helping to resolve choices in the water industry should by now be crystal-clear. Economics does not, of course, provide definitive and clear-cut answers for all, or indeed many, of the choice-situations spelt out in this paper. But these are times when (a) the industry is increasingly concerned with satisfying or rationing demands which are far removed from necessities, (b) the economic constraints appear more severe than ever and (c) institutional developments have presented a new set of problems of allocating resources between (and not just within) the water services. These factors argue strongly for the claim that investment appraisal must be fundamentally economic in nature.

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REFERENCES

1. Hirshleifer, Jack, De Haven, James C., and Milliman Jerome W., 1960, "Water Supply: Economics, Technology, and Policy", University of Chicago, U.S.A., pp.123-4.

2. Walsh, H.G., and Williams, Alan, 1969, "Current issues in cost-benefit analysis", HMSO, London, Centre for Administrative Studies Occasional Paper 11, pp.5-6.

3. Management Accounting Unit, HM Treasury, 1973, "Use of Discounted Cash Flow and the Test Discount Rate in the Public Sector", HM Treasury, London, p.1.

4. Rees, R., 1973, "The economics of investment analysis", HMSO, London, Centre for Administrative Studies Occasional Paper 17.

5. Bromwich, Michael, 1976, "The Economics of Capital Budgeting", Penguin, London, ch.11.

6. Balmer, Richard, 1975, JIWES 29, 390.

7. Pearce, D.W., 1971, "Cost-Benefit Analysis", Macmillan, London, ch.8.

8. Water Resources Board, 1970, "Water Resources in the North", HMSO, London.

9. Water Resources Board, 1971, "Water Resources in Wales and the Midlands", HMSO, London.

10. Water Resources Board, 1973, "Water Resources in England and Wales", HMSO, London.

11. Water Resources Board, 1972, "Desalination 1972", HMSO, London.

12. National Water Council Working Group on Economic and Financial Policies, 1976, "Paying for Water", National Water Council, London.

13. Tate, John Campbell, 1968, "Social Cost/Benefit Analysis and Rural Water Supply - Evaluation of a Proposed Project in the West Midlands", M.A. thesis submitted to the University of Lancaster (unpublished).

14. James, L. Douglas, and Lee, Robert R., 1977, "Economics of Water Resources Planning", McGraw-Hill, New York, U.S.A., chs. 10 and 15.

15. (eds.) Peskin, H.M., and Seskin, E.P., 1975, "Cost-Benefit Analysis and Water Pollution Policy", Public Urban Institute, Washington, D.C., U.S.A.

16. Warford, J.J., 1966, Manchester School 34, 87 (see especially appendix by W. Peters); reprinted in (ed.) Turvey, R., 1968, "Public Enterprise", Penguin, London.

17. Batchelor, R.A., 1972, "Economic Criteria for Domestic Water Metering" (photocopied); a much earlier and (slightly) more accessible version of this paper appeared as Batchelor, R.A., 1970, "The Economics of Domestic Metering", Water Pricing Study Technical Paper No. 2, Water Resources Board, Reading (mimeographed).

18. Rees, Judith A., 1973, The Geographical Journal 139, 20.

19. Smith, R.J., 1974, JIWE 28.

20. Jenking, R.C., 1973, "Fylde Metering", Fylde Water Board, Blackpool.

21. Webster, C.J.D., Ball, E.F., and Rump, M.E., Water, No.11, p.8.

22. "Priority Rating System-Explanatory Notes", Wessex Water Authority, Bristol (photocopied; undated).

23. 1977, "Development Plan", South West Water Authority, Exeter.

APPENDIX

Choice of Discount Rate

Social Opportunity Cost (SOC) The government has advanced the Test Discount Rate (TDR) as a measure of SOC, i.e. of the opportunity cost to the community of undertaking a public sector investment project. In principle, that cost could take the form of reductions in public sector consumption, private sector consumption or private sector investment. The TDR is a version of the SOC which assumes the displacement to be in private sector investment, and it is the appropriate discount rate to use for the establishment of total public sector investment if an economically fair distribution of investment between public and private sectors is being sought. Identification of the social ('internal') rate of return on marginal low-risk private investments, which is what the present 10% is supposed to be, provides a discount rate with which we may assess a public project in terms of its superiority or inferiority to the displaced private investment.

Social Time Preference (STP). This rate indicates the community's view of the value of future consumption benefits worth £1 relative to present consumption benefits worth £1. Since economic costs are literally negative benefits, the same rate relates the value of future resource commitments to present ones. In theory the STP rate can be positive or negative; a negative rate would imply that the community

preferred marginal benefits next year to an equal 'real' value of marginal benefits this year, and this could easily be rationalised in terms of a general expectation of diminishing real incomes in the future. Such expectations are unusual, however, for the experience in most countries is of steadily increasing real incomes if we adopt the medium- or long-term view which is appropriate for most investment appraisal problems.

Does a positive STP rate follow logically once increasing living standards have been assumed? Only if we assume

(i) decreasing social satisfaction from the extra units of real income (and therefore the extra benefits) experienced over time.

And although such an assumption may be deemed reasonable, it certainly cannot be empirically proven. Other arguments which may be adduced in favour of a positive STP rate are:

(ii) that the probability of an end to life in the community (or on earth) in any given future year is positive (albeit small);

(iii) that governments are as likely as individuals to possess Pigou's 'defective telescopic faculty' (i.e. myopia) in assessing the future;

(iv) without a positive rate, the net present values (NPVs) of many future benefit streams will be infinite, which makes decision-taking through NPV maximisation impossible;

and (v) private time preference rates are generally thought to be positive, and the community is the sum of the individuals in it.

(iii) and (v) can be quickly countered. The fact that governments reveal shortsightedness in other areas of economic management is no valid reason to introduce the condition into investment appraisal. And it is unclear why decisions made by the community concerning future provision, being collective by nature, should be related in any way to the private saving behaviour - and therefore revealed time preference - of individuals. The remaining three arguments are not so easily rejected, and together they would seem to consitute a powerful case for positive STP, although on the most plausible guesses of the parameters involved in (i) and (ii) a comparatively low rate would be expected to emerge.

Empirical Estimates. The TDR, first 8% and currently 10% per annum, was originally explained in the following way:

> "This figure is broadly consistent, having regard to differing circumstances in relation to tax, investment grants, etc., with the average rate of return in real terms looked for on low-risk projects in the private sector in recent years." (Cmnd.3437, November 1967, p.5)

STP rates are empirically much less easy to come by, and usually rely heavily on particular assumptions about the form taken by hypothetical relationships linking social utility with income. The latest attempt to put numbers on such theoretical concepts is by M.Fg.Scott (Economic Journal 87, 219), who

(i) transforms a private into a social time preference concept by adopting as income an empirically-measurable 'base-level income' at which the government is assumed to be indifferent between marginal gains accruing to individuals and marginal gains accruing to itself and thus to the community (the Supplementary Benefit level is chosen);

(ii) postulates a pure rate of time preference or "impatience", at 1.5 per cent per annum;

and(iii) estimates the elasticity of the weight given by government to marginal changes in income with respect to changes in income as 1.5.

By forecasting 'base-level income' to grow at 2 to 3 per cent per annum, Scott generates a range of STP rates, between 1.5(2.0)+1.5 = 4.5 per cent per annum and 1.5(3.0)+1.5 = 6.0 per cent per annum.

SOC and STP. In the no-capital-rationing situations in the text, we argued for discounting at the STP rate but somehow still reflecting the displacement of private investment in measuring the opportunity cost of public sector capital use. The formula used should be explained. If a public sector project uses capital resoures, K, all in a base year, then we may suppose it displaces private investment with internal social rate of return,s (this is the SOC rate expressed as a proportion). We can view the annual loss of net benefits from the private sector project as equivalent to K.s in perpetuity. The present value to society of this "loss of net benefits" stream may be shown to equal $K.\frac{s}{t}$, with the discounting carried out at the STP rate, t (also expressed as a proportion). Thus, if K=£100, s=10% per annum, and t= 6% per annum, the opportunity cost of using the £100 in the public sector is given by $£100.\frac{.10}{.06}$ = £167.

DISCUSSION

Author's Introduction

MR. P.R. HERRINGTON introduced his paper by saying that his general aim had been to attempt to explain how economics enabled engineering and scientific demands for more and better water services to be reconciled with limited economic and financial resources. First, he wished to emphasize the sharp conceptual distinction between financial and economic appraisal, since it remained the subject of much confusion. Although the distinction might be less clear cut in practice, he believed the regional water authorities had a prime responsibility when it came to investment appraisal: they should be searching out the economic implications (in terms of benefit flows and the use of resources) of alternative ways of maintaining, expanding, or sometimes diminishing the quantities and qualities of services provided. Financial appraisal, dealing with cash flows and generating the implications of project selection for charges, should be secondary. This did not mean that charges were to be ignored; for economic appraisal could be fashioned, i.e. bundles of supply-augmenting and demand-restricting schemes chosen, subject to given charges constraints, either overall or as applied to individual services.

Turning to the treatment of inflation in discounting, the starting - point, which was always to ignore expected inflation of a general nature, was one of the few propositions about which economists today would agree. There was much uncertainty as to whether future annual inflation would be at 5, 15, or 25 per cent. As it turned out, it did not matter since in economic appraisal the concern was with the *real* resource allocation and thus the *real* opportunity costs of using resources in alternative specified ways. Energy provided a good example of the case where likely differential inflation should be allowed for, the Energy Commission having recently forecast that the "real" price of oil, to which all other energy prices would be related, would rise to'at least double its present value by the end of the century',* i.e. about 3 per cent per annum. Wage rates tended to rise in real terms too, and it was also important to take account of any expected productivity increases which might significantly diminish the necessary amount of variable input to be used in a given project in future years. It was quite wrong, however, to make these adjustments by amending the discount rate, for this would be to assume implicitly that the"real"prices of all inputs and outputs were expected to change at exactly the same rate, which was a most unlikely eventuality.

He hoped he had proved satisfactorily that the social opportunity cost rate, at present reflected in the government's 10 per cent Test Discount Rate, was inappropriate for both cost-benefit and cost effectiveness analysis in the water industry. Indeed, even in the absence of capital rationing it had been shown that optimal project selection depended on the use of a social time preference rate for discounting, the opportunity cost rate being reserved for aiding the assessment of any private sector investment which had been foregone.

Finally, it was necessary to escape completely from long-established and repressive ways of thinking about what was meant by "investment" in the water services. Investment had to be considered broadly to include all forms of demand management as well as supply expansion. Demand management techniques also involved committing resources to gain a stream of benefits, and they should therefore be subject to full appraisal alongside the more traditional, and sometimes socially more expensive, supply system enlargements. The present attitude of the industry in this area left a lot to be desired. For some it would be a great wrench to begin to analyse alternatives and make decisions in this wider framework. Presumably not every chief executive and director of operations would sleep soundly if he had been advised that it was in the social interest for his authority to push resources urgently towards restricting demand and therefore to curtail the throughput of water in his region.

All the contemporary economic and social forces at work, however, indicated that these other types of investment must be enabled to compete fairly with supply expansion for limited resources. Only in this way would solutions to major resource allocation problems be arrived at which were both economically sensible and therefore, in the long run, politically acceptable.

Verbal Discussion

MR. R.N. BALMER (Severn-Trent Water Authority), in opening the discussion, said that the paper covered a lot of ground and that he would like to comment on two of the subjects discussed: demand management and cost-benefit analysis.

* Energy Commission 1977, Working Document on Energy Policy (Paper no. 1), p. 64. HMSO.

Often, demand management was seen only in terms of the impact of price on demand, but demand could also be influenced by education, law, and technological development. The water industry had in fact consistently pursued a policy of conservation by these means, e.g. by talks and through by-laws and the National Water Council approvals scheme.

Price did affect demand but tended to work sluggishly, and it was interesting that it took the educational impact of the 1975-76 drought to cause major changes in the industrial use of water (see reply by Profeesor S.H. Hanke, p. 5 13).

At present, the domestic consumer was not subject to price. However, if water supply and sewage charges were combined, and if the CCA proposals were implemented, it seemed probable that the unit charge for water services would soon approach 40 p/m^3 or £60 per year for a family of four at current prices. Domestic metering would then be economical at 10 per cent savings, which seemed probable and attractive if introduction of meters was selective, two-part tariffs were used, reading was combined with the electricity boards, and the system was designed to influence peak demands.

In cost-benefit analysis, difficulties remained in obtaining good costs, and two serious problems arose in assessing benefits. The first was to agree what should be counted as a benefit and what was to be left out. Taking the example of a life, should the direct economic value alone (perhaps £1-2,000) be taken, or a "social" value (to the family and the community) be included, or should a "perceived" value be used as demonstrated by the costs, for example, of air/sea rescue, which would suggest a value approaching infinity? First-time provision of water services and the investigation mentioned in the paper related principally to health and were bedevilled by this problem.

The assessment of benefits frequently depended on finding out from the consumer directly the value that was placed on, say, reliability. In reality, it was not certain that the consumer knew, nor that views remained constant. During the drought, for example, consumer response would have been a measure of the cost of inconvenience and anxiety: afterwards, the anxiety was forgotten. It was not certain that detailed cost-benefit exercises would ever provide a more certain base for decisions than current "hunch" methods, but further surveys should be undertaken, and the industry should welcome any guidance the author, with his lively mind, could give.

MR. J.S. HETHERINGTON (Binnie and Partners) said that his firm had recently completed a financial management study for Perth, Western Australia. The study had attempted to pull together many of the ideas that were raised in the papers presented at the Symposium. It had considered and presented a range of management strategies covering engineering, planning, economic, and financial options but did not attempt to investigate individual schemes.

To put the study into context,Perth's capital problems were probably more extreme than in most areas of the developed world. This was true for three reasons, namely: the population was expanding rapidly; housing standards were high; and about one-half the dwellings in Perth used septic tanks and there was pressure for all dwellings to be connected to the sewage system.

Mr. Gilliland and Professor Hanke were both specialist consultants on the study and it was not intended to re-cover the topics they had discussed. The study made no attempt to present an engineering or economic appraisal of the investment programme or to provide a rigid blueprint for the future. It

examined the implications of a whole range of physical, economic, and financial options open to the Perth Board.

To do this, the first step was to prepare a base expenditure strategy quantifying the Board's total costs until the end of the century, on the assumption that all the present policies and practices would be maintained. It would readily be appreciated that costs so determined were not likely to be any more accurate than any other long term predictions, but they did enable the financial effects of various options to be studied. The options considered could be split into four categories.

Firstly, there were those options that could improve the cost effectiveness of the Board's operations without altering the standard of service or affecting customers in any way. Leakage was the prime example of this type of option.

Secondly, options that encouraged customers to conserve water were considered. There were three basic approaches, namely: to attack the customer through his pocket; to appeal to his better nature by persuasion; and to limit consumption by legislation, for example by alternating days of watering or the banning of certain appliances or devices. Professor Hanke had dealt with 'attacking the customer through his pocket', and basically the objective was to turn each customer into his own cost-benefit analyst.

It proved difficult to present meaningful estimates of the long term effects of publicity campaigns. Most of the available information was American and one was wary of using it in another country. However, Perth was unusual and its domestic consumption was very high indeed. The metered domestic consumption was about 350 l/person/day. This was because the majority of people in Perth tried to maintain large English gardens in a totally unsuitable climate. Thus, even if one-half the population could be persuaded to convert part of their garden to native plants, the overall savings would be dramatic.

Fourthly, the options involved a lower standard of service. Examples were savings resulting from higher salinity levels in the water supplied, and a higher risk of water restrictions.

Fifthly, options were considered that went far beyond the Board's own field of operations; and these options would involve other authorities. The most important ones were the permanent retention of septic tanks and the introduction of higher density housing. Higher density housing would not only reduce distribution costs but would reduce the possible areas of garden that required watering.

In all cases, it was believed that the potential savings from each option had been presented in a form that would enable rational decisions to be made as the effects on total charges to customers for each option was laid out.

The second part of the study was concerned with financing policies. Again, a range of options was considered that involved different depreciation policies and different policies on developers' contributions.

The Perth Board itself was at present in a period of transition from the old conventional type of structure, based on engineers and billing clerks, to a more modern, management-orientated authority. It would be interesting to see, over the next few years, where their approach differed from that adopted in the UK.

MR. J.A. YOUNG (Wessex Water Authority) said that he had to take issue with the author's introductory statement that in the 1950s and 1960s water supply schemes were too often planned and executed without any rigorous justification. Certainly as far as Wessex was concerned, a substantial supply deficit was inherited which was incapable of meeting even a slight drought, let alone the 1 in 1,000 year event of 1976. The author suggested that he expected to inherit a system capable of meeting a 1976 drought which, of course, was never implied. This would be a major waste of resources.

The author went on to mention that the capital investment ceiling was determined politically at national level. This was the case initially, but the effect of interest rates, inflation, and the inability to self-finance (Price Commission,etc.) soon increased the proportion of revenue budgets devoted to serving capital, in some cases to over 50 per cent, so as to limit capital expenditure by the local political effect of the level of charge. In fact there was pressure nationally to spend more due to unemployment and the surplus capacity in the civil engineering and pipe industries, brought about by the false dream of the early 1970s "dash for growth" by the Government of the time.

Referring to 'Choices for Consumers' (p.6 15), another legend dear to the heart of economists was the fact that engineers felt they knew best and interpreted the standard of service necessary at an unnecessarily high level which would not be accepted by the man in the street if he was presented with the facts and the economic costs.

Recently, the Wessex Water Authority considered water supply standards of service in its annual plan document. Strange as it might seem, the standards postulated were considered to be too low and it was decided that restrictions were only tolerable at 15-20 year intervals, not the 1 in 10 years suggested. In the event, it had to be accepted that costs would dictate, as set out in the paper, a fairly long time scale but the standards had to be achieved.

Consumer choice was also being reflected in the provision of "first time" rural sewerage schemes which would not be accepted unless 70 per cent of the potential consumers agreed to pay the connection and annual charges.

In 'Demand Management' (p.6 16), Wessex was, at present, carrying out field trials on variable flush cisterns as a resource option. The installation costs and water savings of variable flush cisterns were being established to see whether the savings of water by a regional installation of these cisterns at the Authority's expense would be a cheaper option than the development of the equivalent new water resources.

As far as a 'Points System' (p.6 17) was concerned, the complexity of the Wessex Priority Rating Scheme resulted from it incorporating the DoE's 14 priority classifications system for annual planning purposes. The original scheme had eight headings and was therefore less complex. However, it yielded useful benefits, especially in demonstrating to those competing for scarce resources for their own area that at least an attempt at objective assessment had been made.

He further wrote about metering, which was discussed in the paper under 'Demand Management'. As Chairman of the sub-group which produced the metering paragraphs in the NWC document *Paying for Water*, he stated that the 20 per cent saving indicated was completely tentative, based on a study of foreign experience, especially the Netherlands where work was carried out in 1967 in areas that were metered and unmetered, indicating a 40 per cent saving in metered areas. It had been stated in the report and elsewhere (Fig. 1) that there was

a need for further studies to refine it. His own Authority had sought, so far unsuccessfully, for Government approval to pursue such studies.

With the Mansfield comparison with the Malvern studies now available, the figure did now seem optimistic, but installation costs were also crucial in metering new areas and large scale experiments were required.

Foreign evidence was not clear cut because metering appeared to have been installed in many cases merely for the lack of a practical alternative rather than for equity or economic evaluation. The value of metering was also often vitiated by unsuitable tariffs which gave initial free or cheap allowances, minimum charges that were seldom exceeded, out of date charging bases, or failure to meter multiple dwellings individually which formed a large part of the housing stock.

In the U.S.A. where tariffs in general were more commercially orientated, there was a move towards increasing block tariffs, i.e. higher charges for units consumed, for higher rates of consumption, and for the use of seasonally adjusted tariffs, so as to reflect the increased marginal cost of external summer use when resources were at the minimum.

There was much to be said for offering the domestic consumer the option of a meter at his own expense, if he felt hard done by on existing rateable value tariffs. This was now being done by two water companies in the UK.

Given the present pressure on resources of every kind, it did seem inevitable that a demand related charge for domestic consumption must come sooner or later.

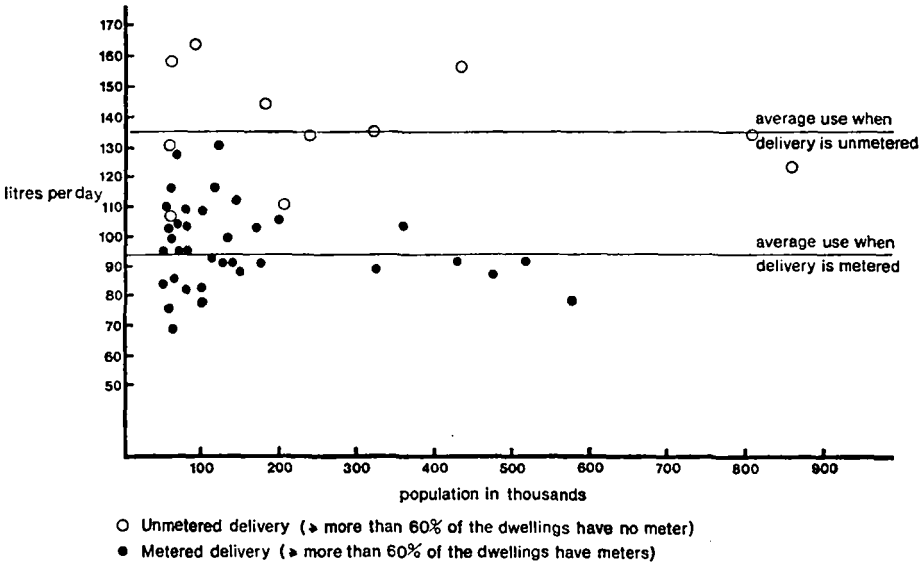

Fig. 1. Water consumption per capita in areas of supply with a population above 50,000, Netherlands 1967 (from General Report No.2, IWSA conference, Amsterdam, 1976, by J.A. Young). *Reproduced by kind permission of the International Water Supply Association.*

MR. W.J.F. RAY (Thames Water Authority) commented that although a test discount rate of 10 per cent had no doubt been used in the past for the appraisal of capital projects with no allowance for inflation, it was doubtful if this simplistic approach was generally followed by engineers. Certainly, other rates had been used on occasions to check the sensitivity of the conclusions reached with a 10 per cent rate.

If this rate was used, there was surely a case for at least allowing for inflation at 5 per cent: this was virtually equivalent to using a social time preference rate of 5 per cent with no inflation,as suggested by the author. The effective discount rate was, for example, important in analysingthe classic water industry problem of the options of either laying a large main now to meet present demand and anticipated growth, or alternatively, laying a smaller main now followed by duplication in several years' time. In practic, of course, considerations other than engineering economics might well be of greater significance in determining the optimum solution.

In the paper, there was a reference to detection and elimination of leakage, which, it was suggested, was of the order of 25 per cent. This might be compared with an actual oonsumption appraisal of the water distribution system of a large city which showed unaccounted water as 15 per cent of the total quantity supplied. The study was facilitated by the system being fully metered, although there was no systematic leak detection and little maintenance. Certainly since reorganization, water distribution systems in the UK were efficiently maintained. Would the author give evidence for his 25 per cent leakage figure?

Individual water authorities were involved with promoting and implementing large numbers of capital projects at any one time. For example, the Thames five-year programme contained some 400 projects, each valued at over £150,000, of which about 100 were presently at the construction stage. It was quite impracticable and uneconomical to apply detailed cost-benefit analysis to all projects on account of the difficulty in obtaining reliable input data on the benefit side. The author accepted that some form of points system was of value: however, this should not preclude pursuance of the cost-benefit approach.

MR. J.A. FOSTER (Northumbrian Water Authority) referred to the specific issue of priority and, in particular,of ranking systems. The acid test of any such system was that it should produce priorities which accorded considerably with informed subjective judgement, and he suspected that the weightings used in many points-rating systems were "tuned" to achieve this.

His own Authority was seeking to develop a system whereby the weight given to the various factors influencing priority was derived from the subjective ranking of a sample number of varied schemes. The influential factors were seen as the "planning gap" (the gap between the present level of service and the "target" level of service), cost, the number of beneficiaries, and the purpose of the scheme. He did not regard the DoE purpose categories as appropriate, as they were not mutually exclusive: some combination of service area and beneficiary would be preferable.

To derive the weight to be given to each of these factors, the "direct consensus" technique was being examined, in which any number of people could carry out a subjective ranking exercise on the sample number of "bench mark" schemes knowing, for each scheme, details of the various factors. A similar ranking exercise had also to be carried out for the various purposes to give these a relative value. Multiple regression analysis could then be used to determine the weight to be applied to the various factors influencing priority,

which could then be applied to the remaining schemes to give an overall ranking.

The problems were self-evident. First, the need for "target" levels or standards of service. Next, which cost should be used? Then, who should carry out the ranking exercise? Finally, it was difficult, as yet, to obtain the relevant information for each scheme required for the exercise.

Naturally, any list of priorities would be subject to political modification. However, it was hoped that this would be done after, rather than before, the ranking exercise, so that any political modifications would be made in the light of the fullest information available.

All the foregoing assumed that the schemes to be ranked had already been justified in themselves and that the question was not whether but when they should be carried out where expenditure was constrained either by availability of capital or by the charging consequences of investment for consumers.

A paper setting out the proposals in detail had been prepared and was being discussed with colleagues in some other RWAs and with the NWC, but he would welcome contact with anyone else who was interested or who had suggestions to offer.

Author's Reply to Discussion

MR. P.R. HERRINGTON, in reply to the discussion, wrote that it was true, as Mr. Balmer seemed to have implied, that some economists equated demand management with the impact of price on demand, but it was a charge to which he himself thought he could confidently plead not guilty. Changes in by-laws and water usage technology obviously provided much scope for demand management (though a cost-benefit analysis was essential in all cases), and the Building Research Establishment (BRE) was now engaged in estimating the potential savings.* For example, it had been estimated that if the one million w.c. pans installed each year in new buildings or as replacements were both low volume (4.5 litres) and fitted with a syphonic flush mechanism (as developed at the BRE), the resulting annual cumulative reduction in water usage would be about 35 per cent of the average annual increase in unmetered consumption over 1965-75. Talks were certainly a legitimate part of an authority's public relations, but the effect on the use of water was probably zero.

The behaviour of metered demand in England and Wales since 1970 was odd and it had not yet been shown which factors were responsible for what proportion of the downturn. A number of theories were still on offer, including the real price of water as both input and effluent, although the combined effect would probably turn out to be dwarfed by the impact of the drought. A severe drought now and then would produce enormous social benefits in terms of subsequent resource savings; indeed, it was time more people spoke up in favour of droughts!

The domestic metering debate would doubtless continue to move forward slowly. Universally, the economic advantages and disadvantages seemed finely

* See ref. 21 in the author's paper and his fuller summary of demand management possibilities in Drudy, P.J. (ed.) 1978, Water planning and the regions, p. 41. Regional Studies Association discussion paper no. 9.

balanced, but selectively the potential net benefits were sometimes very clear. However, in all the present domestic metering experiments there wasn't any community that was actually being switched over from charges based on rateable value to unit quantity charging. There was a great need for more evidence on the effects of such charges.

Mr. Balmer's statement of some of the difficulties attached to benefit estimation was salutary. Part of the provision of the water services had sizeable external benefits, which put them in the "public goods" category and ensured that the market mechanism failed as a measure of worth. Evidently, some political valuation was required, and the advantage lay in making it explicit and consistent: but it was important not to overstate the proportion of, for example, the public water supply that could be slotted into this category. A large and probably increasing part of the demand for water was free of significant spillover benefits.

Despite Mr. Balmer's strictures, he remained convinced of the desirability of subjecting decisions about reliability to much more analysis than they had been hitherto. He did not know of any viable defence of "hunch" or rule of thumb procedures for dealing with such matters.

Mr. Hetherington's description of the Perth study was a good example of the wider framework for analysis for which he himself had been arguing.

Replying to Mr. Young, he thought the claim for Wessex that in 1974 it would have been incapable of meeting even a slight drought was not one that could be shared by many authorities. He had studied in detail the demand forecasts being used by local water undertakings (LWUs) in their planning in the 1960s, and many of them would not have lasted five minutes if properly challenged in public inquiries. Anyone doubting this should examine the LWU-based forecasts included in the Water Resources Board's England and Wales report of 1973: some of them were presumably included for their entertainment value rather than as serious planning tools!

He felt that investment appraisal, which was subject to constraints on charges as introduced by local political factors, had been dealt with explicitly in the paper.

Concerning standards of service imposed by engineers, his criticisms stemmed from the principle conveniently set out at the head of Mr. Walker's paper (p.7 1), that individuals were generally the best judges of their own welfare. Consumers - or, as a second best, authority members - might opt for either higher or lower standards than the engineers:whichever, it was a superior decision-taking mechanism to the present practice.

The Wessex Water Authority's interest in variable-flush cisterns as a possible alternative to new source developments and in carrying out a metered charging experiment were to be welcomed. It was surprising and highly regrettable that political interests were preventing the acquisition of more knowledge about the effects of charging on domestic consumers in Wessex, just as earlier similar interests had eliminated charging from the scope of the Mansfield/ Malvern studies.

Replying to Mr. Ray, he claimed that a recent water services seminar at York University had surveyed project appraisal by the ten water authorities and had found that the most popular discount rate used was 10 per cent, i.e. the Test Discount Rate. If the rate was being adjusted downwards in some authorities to allow for inflation, that revealed a basic misunderstanding of the

Test Discount Rate, although it could be that by arithmetic accident rates of interest emerged as a result which were similar to his own preferred social time preference rate. There were now some signs that the Treasury might be about to lower the recommended rate.

Concerning leakage, the source of the 25 per cent figure was the First Report of the National Water Council's Technical Working Group on Waste Water, published in November 1976. The group had in fact estimated unaccounted-for water at an average of around 25 per cent, but identified the fact that "other" uses, e.g. mains scraping, hydrant testing, etc., probably used only one or two per cent at most. The 25 per cent estimate was now being used by some authorities in building up demand forecasts using the analytical or "component" methodology.

Mr. Foster had raised some important questions about the use of priority ranking schemes and was evidently aware of the criticisms that could be made. He himself was all in favour of exploring the scope for such systems, but he thought that there was now an urgent need for inter-authority research, especially into the derivation of scores for the various benefit categories and the incorporation of both capital and operating costs. If the weightings used for benefit scores did in fact reflect subjective judgement, whose judgement was it? Was it the judgement of officers, members, or consumers, or all three? This came back to the question of who was to fix the "target" standards of service. It also seemed desirable that a robust points system should have the capacity to throw out some schemes altogether.

He had the impression that progress was already being made in bringing forward some of the'practical procedures'that Mr. McIntosh (see p.5 14 and Professor Hanke's reply, p.5 15) rightly wanted to see in the gap between theory and present practices. For example, both the Water Research Centre (in report TR 61) and the Midlands Sub-Group of the Directors of Finance Capital Appraisal Working Party (in draft proposals) had carried out useful studies of cost estimation for project appraisal: and many authorities, as had been noted before, were now developing or using points systems to attempt to introduce precision into the identification of priorities. He agreed, however, that options for individual projects were often too limited; and the alternative of not taking action was usually the most under-investigated option of all.

7. POSSIBLE POLICIES FOR THE FUTURE

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This paper is based on the presumption that individuals are the best judges of their own welfare, and should as far as possible be enabled to make their own decisions in the light of the costs involved. As this requires an improved understanding of costs, the first half of the paper indicates how present economic and financial principles need to be reconciled.

Because of the nature of the water services, many decisions will continue to have to be taken on behalf of large groups of individuals. The second part of this paper considers how far these decisions can be delegated for various aspects of the water services and to what extent common policies are needed for the future.

INTRODUCTION

Private Goods and Social Goods

Many policy issues in the water services are concerned with priorities: which services should be expanded or improved now and which should not? Where "private goods" (and services) are sold in the market at prices which cover costs, it can be argued that these decisions can best be taken by individual enterprises in the light of their customers' demands. For "social goods" (and services), which may be enjoyed in common by a number of people, individual choice no longer provides a sufficient guide to priorities. This may arise because "social goods" (like defence or police) cannot be restricted to those who are willing to pay or it may arise because one individual's decisions may affect his neighbours.

This distinction is important in determining priorities for the water services. To the extent that individual services are "private goods" the best policy may be to work out what they really cost, to present these costs to the customer and to let him make the decision. To the extent that they are "social goods" it is necessary to agree who is best placed to make decisions on behalf of the public and as far as possible to quantify the benefits as well as the costs. These are the questions with which this paper is mainly concerned.

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Without necessarily using these terms, much debate within the water services is concerned with the question whether particular services are "private goods" or "social goods". Because of nineteenth century concern over waterborne disease there has been a tradition that the water services are "social goods" to be bestowed upon the grateful population through the wisdom of municipal government (and paid for out of the rates). Only gradually have certain services (e.g. industrial water supply, trade effluent charges and abstraction charges) been treated as "private goods" to be charged by volume and therefore expanded in accordance with customers' demands.

On the face of it, the 1973 Act (1) marks a radical change in that tradition. It suggests - except so far as it has already been modified by the 1976 Act (2) - that charges for the water services should be determined like charges for electricity, gas and telephones. Section 30 prescribes that charges for "services, facilities and rights" should be determined having regard to the costs of supply and without undue discrimination between classes of consumers. However, the 1973 Act also recognises that the water services are different from other public utilities in prescribing the hybrid form of organisation which allows water authorities much more freedom to determine their own priorities than the regional boards of other public utilities.

The distinction between private goods and social goods is not clear-cut in the water services but it does provide a useful basis for discussion. The need is to soften the polarisation of views in which "economists" tend to regard it as desirable to measure and price all of the water services as "private goods" and "engineers" tend to believe that they are always in the best position to decide on the level of service which needs to be provided to the public.

Determination of Costs

As mentioned above, when decisions are delegated to customers by charging for "private goods", it is essential to any rational pricing policy to determine the costs involved. This is also necessary for rational decision-taking on the provision of "social goods", although costs can sometimes be ignored more easily in that case by declaring those social needs to be essential.

In this country, Treasury policy, exemplified in the White Papers on the Nationalised Industries of 1961 (3) and 1967 (4), is that public sector prices should as far as possible reflect costs. This is intended at one and the same time to avoid the over-expansion of nationalised industries and to reduce their borrowing requirements. It is also intended that by selling the output of the nationalised industries as far as possible like "private goods" Government intervention in decision-making can be avoided, which marks an important distinction between Government departments and public corporations.

In practice, of course, where the costs involved are thought to be too painful to the customer (where the industry has a monopoly) or to the industry (where the customers are able to meet their needs elsewhere), successive Governments have intervened in contradiction to their own policies declared in the White Papers referred to above. The 'fight against inflation" has resulted in policies oscillating between holding down public sector prices in an attempt to influence other prices and wages and putting them up in order to reduce the public borrowing requirement and therefore the inflationary growth in the money supply.

Worse still, the effect of inflation has been to confuse the nature and level of the costs involved. Despite the sophistication of present-day techniques, the result of this confusion has been to make costing more difficult and controversial now than it has ever been.

Public Decision Making

The other main topic of this paper is who should make the decisions on behalf of the public where, for one reason or another, these decisions cannot be left to individual customers through cost-based charges for the water services.

As indicated above, this is the nature of "social goods". Even if it is agreed to leave the decision-taking to the customers whenever possible, there are many instances in which this is quite impossible. The quality of public water supplies is a good example. Here everyone within a particular supply zone must accept the same level of quality, and in any case they depend on expert advice as to the quality of water which is thought to avoid detriment to health and the cost of improving water quality. The quality of rivers and estuaries provides another example. Here again, those who use a particular reach of river all have to accept the same quality objectives and interesting issues arise as to who should pay for the achievement of whatever quality objectives are adopted.

In other instances the need for decision-making on behalf of the public as a whole is less clear-cut. Individual customers can decide how much water they wish to use and, particularly if it is worthwhile to provide them with a meter, these decisions can reasonably be left to them. However, someone still has to decide on behalf of these customers on the standard of reliability which should be provided (unless very sophisticated meters are used instead). It may also be possible by charging in accordance with the volume and strength of discharges to the sewer (and to streams) to allow people to decide for themselves how to share the capacity of the environment to accept effluents, but here again a collective decision is needed on the overall quality objectives to be adopted.

There are many levels at which these collective decisions can be made (or avoided). In this country at present they could be delegated to divisional managers (or their management teams), to the chief executives and directors of water authorities (acting

collectively or individually), or to the chairmen and members of water authorities, or committees acting on their behalf. Where "national policies" are required, these may be evolved in discussion between water authorities, the National Water Council and Government Departments, or they may be imposed by Ministers, or civil servants acting on their behalf, or by a National Water Authority. To a growing extent, consultation with anyone affected (and many who are not) is expected before decisions are taken, and neither can we ignore the requirements of national legislation in the fields of health and safety, consumer protection and the rights of employees. Finally, supranational policies may well be imposed by the EEC, or accepted from WHO and other international organisation.

Members and managers of water authorities (and most other industries) are frustrated by the effects of this hierarchy of decision-making, and yet at the same time the public are said to be concerned at their inability to influence public decision taking. It is hoped that the policies suggested in this paper would make matters better rather than worse.

DETERMINING COSTS

Definition of Terms

In order that customers should be encouraged to make their own decisions in the light of the costs involved, it is necessary to determine these costs. This involves a number of practical problems and, more important, requires a common understanding of the nature of costs.

The following principles are recommended in an attempt to bridge the unfortunate gap which often appears to exist between "accountants", who tend to be concerned with historic costs, and "economists", who tend to be concerned with future costs:

(a) the net value of an asset at a point in time is equal to the discounted value of future net earnings;

(b) net earnings over a period of time are equal to the difference between the extra revenue accruing from the asset and the extra operating costs incurred;

(c) depreciation over a period of time is equal to the reduction in the value of an asset over time due to the reduction in the discounted value of future net earnings;

(d) it follows that the net value of an asset at a point in time will equal its initial (gross) value less accumulated depreciation;

(e) operating profit over a period of time is equal to net earnings less depreciation over that period of time; and

(f) return on capital over a period of time is equal to operating profit expressed as a percentage of the average value of net assets over that period of time.

The return on capital which is achieved in practice will depend very much on the objectives of the enterprise. If, for example, it is only required to "break even" after meeting interest charges, then the operating profit will need to match the interest charges for that year and no more. Alternatively, a percentage return on capital may be prescribed (e.g. by the Treasury) equivalent to an operating profit which will probably be more but may be less than interest charges for that year. Finally, the objective of a private firm may be to achieve the highest return on capital that is possible within legal constraints.

It is also worth remarking on the alleged distinction between "profit making" and "non-profit making" enterprises. This tends to cause confusion because the return on loan capital (i.e. interest) is usually regarded as a cost to be charged before determining the profit or loss, whereas the return on share capital (i.e. dividends) is not regarded as a cost and is paid for out of profits. From the economist's point of view, an adequate return on capital is part of the costs whether it is paid to loan-holders in interest or to share-holders in dividends. This normal return on capital is not an optional extra: it is essential to the survival of the enterprise.

Marginal Costs

Strictly speaking, marginal cost or incremental cost is the excess of (a) the present value in that year of system costs with a unit permanent output increment starting then, over (b) the present value in that year of system costs with the unit permanent output increment postponed to the following year (5).

Where demand on the system increases (or falls) unexpectedly, this incremental cost until capital investment has been re-optimised is known as short-run marginal cost. Where future demand is correctly anticipated by new investment, the long-run marginal cost of meeting this demand on a continuing basis can be derived from the investment appraisal and is equivalent to the "discounted unit costs" quoted by the Water Resources Board (6) and subsequently.

Incidentally, if the system is already optimised, short-run marginal costs (for small changes in demand) should equal long-run marginal costs. For example, if a pipeline is running at its design capacity, incremental pumping costs per unit of flow should equal the total costs (including capital charges) per unit of flow of providing additional capacity. If system reliability is optimal, the short-run marginal cost (to the community as well as to the water authority) of supplying more water from the existing system by increasing the risk of restrictions and disconnections should equal the long-run marginal cost of adding to the new system. In practice, of course, the lumpy nature of new capacity means that short-run marginal costs are relatively low after new capacity has been commissioned, and relatively high immediately before the next tranche of capacity is completed.

Except where extra supplies can be used on a temporary basis, long-run marginal cost usually provides a much better basis for charges than short-run marginal cost because consumers usually need a guide to their long-term decisions on methods of production (and water-using appliances if household supplies are metered).

It is important to note that marginal costs have nothing to do with the accounting distinction between "fixed" and "variable" costs. However, long-run marginal costs can be reconciled with the accounting terms defined above. Indeed, the appraisal of new investment, the determination of marginal costs and the formulation of depreciation policy can be regarded as three aspects of the same question. It is not pretended that the reconciliation outlined below can be precisely achieved in the real world, but it is believed that an acceptance of the principles outlined would help to illuminate real-world decision-making.

Illustrative Example

Assume first that there is no inflation (i.e. general price levels are stable) and an enterprise proposes to invest in a single project costing £1000 with no running costs and a known useful life of 20 years (and a residual value of zero). The capital cost can be borrowed at an interest rate of 5% and therefore an investment appraisal shows this project will be worthwhile if the consumers are prepared to pay £80.24 per annum (equivalent to the 5% annuity over 20 years). If the whole of the output can be sold each year and if the object is to hold prices steady, this will be the revenue which ought to be recovered each year. Assuming that economies of scale, technological progress and external effects are not significant, these accounting costs will equal long-run marginal costs.

In this case the net earnings of the project will be £80.24 per annum (for 20 years) and Table I below demonstrates that this will precisely match interest on the outstanding loan plus depreciation calculated in advance on an annuity basis. Moreover the present value (at 5%) of net earnings over the remaining life will equal the book value of net assets (gross investment less accumulated depreciation) which also equals the outstanding loan (assuming depreciation is used to pay off the loan):

TABLE I

(1) Beginning of Year	(2) Revenue Required	(3) Outstanding Loan	(4) Interest Required	(5) Depreciation Provision	(6) PV of Future Net Earnings
1	£80.24	£1000.00	£50.00	£30.24	£1000.00
2	£80.24	£ 969.76	£48.49	£31.75	£ 969.76
3	£80.24	£ 938.01	£46.90	£33.34	£ 938.01
18	£80.24	£ 218.52	£10.92	£69.32	£ 218.52
19	£80.24	£ 149.20	£ 7.46	£72.78	£ 149.20
20	£80.24	£ 76.42	£ 3.82	£76.42	£ 76.42

This simplified example illustrates several important principles which also apply to more complicated appraisals which have to allow for changes in net earnings caused by changes in demand, or increased running costs, or improvements in the technology of new projects:

(a) depreciation is not directly concerned with physical deterioration or with replacement - provided the enterprise is in good financial standing when it becomes more economical to replace the asset than to keep it going it can borrow the money needed to finance this replacement;

(b) wherever economic analysis shows that the discounted earnings from a project are at least equal to its discounted cost, it will be possible to construct in advance a depreciation schedule which will write off the project over its useful life and match the net book asset value to the present value of future earnings; and

(c) provided the pattern of output and operating costs is correctly forecast in advance, there is no need for charges to fluctuate over the life of a project - they can be arranged to remain stable or to increase steadily or fall steadily to match in with the costs of subsequent projects.

What this demonstrates is that, in the absence of inflation, there need be no contradiction between economic appraisal and financial appraisal, or between marginal costs and accounting costs, provided people are agreed on the assumptions which underlie any investment appraisal. It is worth remarking that for many long-lived projects it would become necessary to capitalise interest for many years after completion - which would be a proper reflection of the increase in the real value of the assets over the early years in which output was low.

Effect of Inflation

Now assume that inflation is running at a steady rate of 10% per annum. If the lender is to receive the same real return as above, there are two alternatives:

(a) a fixed interest rate of 15½% (which - but for taxation - would enable him to spend 5½% and reinvest the 'inflation premium' of 10% at the end of each year), and

(b) an 'index-linked' rate of 5% (either a 5% dividend on share capital - of which the purchasing power would need to be preserved - or a 5% 'index-linked' loan).

These alternatives come to the same over the life of the project i.e. the present value of charges will be the same and the lender will obtain the same real return. However, the profile of capital charges over the life of the project will be very different, as Table II shows:

TABLE II

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(a) 15½% fixed interest			(b) 5% index-linked		
End of Year	Interest Paid	Depreciation Provision	Total Charge	Interest Paid	Depreciation Provision	Total Charge
1	£155.00	£ 9.20	£164.20	£55.00	£ 33.26	£ 88.26
2	£153.57	£ 10.63	£164.20	£58.67	£ 38.41	£ 97.08
3	£151.93	£ 12.27	£164.20	£62.42	£ 44.37	£106.79
18	£ 57.64	£106.56	£164.20	£60.71	£385.37	£446.08
19	£ 41.12	£123.08	£164.20	£45.63	£445.13	£490.76
20	£ 22.04	£142.16	£164.20	£25.70	£514.12	£539.82

Columns (2) and (3) of Table II were constructed in the same way as columns (4) and 5) of Table I, by calculating the 15½% annuity over 20 years. It will be seen that this results in a constant total charge in money terms. If straight line depreciation had been used, the total charge in column (4) would have been even higher relative to column (7) in years 1, 2 and 3 and even less in years 18, 19 and 20. Columns (5) and (6) of Table II were constructed by multiplying the corresponding figures in columns (4) and (5) of Table I by the general price index i.e. 1.10 at the end of year 1, 1.21 at the end of year 2, and so on. This results in a constant total charge in real terms.

The crucial difference occurs in year 21, if the enterprise decides to stay in business and has to replace the asset at a cost of not £1,000 but £6,727 (the effect of 10% inflation over 20 years). Using method (a), the charge at the end of year 21 would need to be £1104.57, an increase of nearly seven times on the charge in the previous year. With longer-lived assets the jump would be even more dramatic. Using method (b), the charge at the end of year 21 would be £593.77, an increase of 10% on the previous year and in line with the increase in general price levels.

Table II demonstrates that, in the presence of inflation, historic cost accounting will tend to distort the costs it is intended to illuminate. For example, areas with relatively old assets will appear more efficient than they really are, and their prices will be artifically low. If expansion or replacement is required, prices will have to jump, and this may have the disastrous effect of choking off the increased demand the new assets were intended to meet. New business will appear financially unattractive and the appraisal of new schemes will be distorted. This means either that prices will be unnecessarily high in areas with new assets or that high connection charges may be required to avoid a sharp increase in the prices charged to other customers.

The only way to avoid these distortions is to charge depreciation at current price levels and the non-inflationary interest rate on assets valued at current price levels.

This will result in the 'proper charges' illustrated in column (7) of Table II.

The enterprise can then discharge its obligations to its lenders in either of two ways. If loans are index-linked, interest charges (at 5%) and repayments can both be linked to the general price index. With fixed interest loans, the enterprise will need to increase its monetary debt in the early years to cover the inflated interest rate of 15½%, and subsequently run down and extinguish this debt from the higher prices (in money terms) charged in the later years.

Implications for Costing

The theory outlined above is intended to demonstrate why it is so difficult to reconcile present methods of financial appraisal and economic appraisal in the presence of inflation, and to suggest that the introduction of some form of current cost accounting would assist this reconciliation. However, this would still leave several difficult problems unresolved.

First, people tend to be concerned that the determination of costs and therefore charges in this way involves a judgement of the future which is inevitably fraught with risks. However, as indicated above, this judgement goes no further than that which is needed anyway in any system of investment appraisal. Depreciation policy inevitably involves a judgement of the future, and the principles outlined make this explicit instead of implicit.

Secondly, and more important, actual money interest rates (adjusted downwards by the anticipated rate of inflation) may fall short of the real rate of return prescribed for economic appraisal. This may arise partly because the rate of return used for economic appraisal includes a premium intended to compensate for the over-optimism of most appraisals. However, if appraisals are realistic then it could penalise capital-intensive schemes unnecessarily and ultimately increase the charges payable by consumers. To put this another way, the message presently conveyed by the money interest rates charged by the Treasury does not appear to be consistent with the message conveyed by the test discount rate of 10% (in real terms) they prescribe for economic appraisal.

Thirdly, if charges based on the real rate of return are passed on to consumers (as they need to be to test the worthwhileness of new investment) they could ultimately raise substantially more revenue than water authorities need to meet their present accounting obligations. This problem is discussed at more length in reference (7).

DECISION MAKING PROBLEMS

General Philosophy

As indicated above, this paper rests on the general proposition that, wherever possible, individuals should be presented with an indication of long-run marginal costs and

allowed to decide for themselves how far their water services should be expanded. However, this would sometimes be extravagant, where the costs of costing and measurement are excessive, and sometimes impracticable, where "social goods" are involved. In these cases, the nearest we can get to individual decision taking is to quantify the costs of service to groups of consumers at alternative standards of service and delegate the decision to the lowest competent level in the hierarchy outlined earlier.

The lowest competent level will vary according to the nature of the decisions involved and the ability to separate costs. One of the most significant benefits of the 1973 reorganisation has been the clear cut appreciation by water authorities that improvements started this year will put up charges next year, which has probably done more to improve the quality of investment appraisal than all the academic papers ever written.

The danger is that equalisation of charges within water authorities may take away any financial incentive to economy at divisional level. This is not to suggest that divisional managers are naturally extravagant, but to air the possibility that local accountability might be improved if their customers could see the benefit of local economies in lower bills (and vice versa). This would require a divisional accounting system for capital assets as well as running costs.

The dilemma is that this runs counter to another benefit of the 1973 Act, which has been the ability of water authorities to choose the most economical solution for a catchment as a whole without regard to boundaries between local authorities and between services. Where, for example, the effluent from an upstream sewage treatment works has to comply with an abnormally rigorous standard in order to protect a downstream water intake, it is possible to argue indefinitely over cost allocation. The strength of the present system is that water authorities are big enough to employ competent staff to make the technical assessments required and (hopefully) small enough that the members of water authorities can make decisions on behalf of the public where commonsense is more important than or complementary to cost benefit analysis.

Unfortunately, however, this is not the way water authorities are seen by some local and regional newspapers or by some local authorities. When water authorities are branded as 'undemocratic' it is not always clear whether their critics would be prepared to make the painful decisions between priorities which have to be made by water authorities or whether they just want to spend more money locally out of national taxation.

River Quality Objectives

Consistent with the philosophy of taking decisions at the lowest competent level, quality objectives for inland waters (and tidal waters too) appear to be a matter for water authorities to decide (or local committees based on smaller catchment areas where appropriate). Having proposed a broad philosophy at national level (8), the way to put this into practice will be by

local consultation as to local priorities. Because public health is rarely at risk due to polluted rivers or even polluted beaches, priorities will usually depend upon recreation, amenity, aesthetics or local pride, and these are all matters on which a representative local body can reasonably be expected to take decisions on behalf of the public. Where the public have strong views, it is then open to them to influence the decisions of water authority members through local pressure groups.

This unsophisticated but potentially effective system must depend on the open availability of information, which places a heavy responsibility on the officers of water authorities to summarise the present state of their rivers in a way which is both comprehensive and comprehensible and to indicate the potential costs of improvement so far as possible.

This may run contrary in some respects to the present policy of the European Community, but it appears to be entirely consistent with the cogent arguments advanced by this country's representatives in the Council of Ministers and also in several debates in the House of Lords. In response to the EEC argument that "equality of competition" demands uniform emission standards, our representatives have argued that countries should be free to make the best use of the assimilative capacity of their own environment. Where the EEC have accepted environmental quality objectives, the need is to obtain realistic values in the appropriate Directives and local discretion as to the application of those Directives.

Drinking Water Quality

Where drinking water quality has a demonstrable effect on health, this is an area where regional autonomy, or even national autonomy, is more difficult to sustain. The problem is that the medical risks are usually difficult to define and the question then is whose judgement can we rely upon?

In this country we pride ourselves that the bacteriological water quality of drinking water is second-to-none, but it has to be recognised that the reorganisation of 1973 revealed a number of smaller systems which fell short of the high standards which tended to be regarded as normal. Without necessarily accepting the proposed EEC standards of perfection for lead in drinking water, it also has to be recognised that the survey of lead in tap water prompted by their proposal has reminded water engineers and scientists that plumbosolvency is not necessarily restricted to soft water.

In these fields international co-operation is needed to improve the understanding of the relationship between drinking water quality and health. While no-one has yet established that re-use of sewage effluent has any harmful effects, the water industry must accept the onus of ensuring that no harmful effects are likely and the cost of this work is such that research needs to be sponsored at national or supranational level.

It tends to follow that standards for substances which are thought to be harmful will tend to be set at supranational level,

in which case it is important that they should carry an indication of the safety margins included and the consequences of failure to comply. Whether or not such standards are intended to be 'mandatory', those who work to less rigorous standards will need to be able to justify their decisions very clearly. In this country we now have the benefit of the Joint Committee on the Medical Aspects of Water Quality (9), which is composed of a number of outstanding and independent medical specialists, as well as representatives of the Government Departments concerned and the water industry. This forum will help water authorities to decide on behalf of their customers where the medical risks are such that urgent expenditure is needed and where it makes sense to stage any improvements over many years.

There are other aspects of water quality (e.g. colour, taste and odour) which do not affect health directly, and on matters such as these water authorities would seem entitled to set local priorities without having to comply with national or international standards.

Reliability Standards

The 1975-76 drought was illuminating in many respects. It reminded water engineers and scientists that the reliable yield of a source in a drought is less than the analysis of past records might suggest, because at the time no one has any idea of when the drought will break and therefore restrictions are imposed long before reservoirs are fully drawn down. On the other hand, it demonstrated the variety of expedients which may be available to increase yields and to discourage water use. It also demonstrated the difference in reliability standards across the country, the areas which were worst affected generally being those where new source development had been delayed for one reason or another.

The interesting question is therefore whether reliability standards can be left to local decision, on the principle that local communities can best decide for themselves whether they are prepared to provide the reservoir sites and the other resources needed to increase the reliability of their own water supplies. Unfortunately, the answer appears to be that divisions cannot be left to decide for themselves. If one area within a water authority is suffering acute inconvenience from standpipes or disconnections, it is clear that the water authority is expected to put this right without regard to past history.

Can water authorities be left to decide for themselves? In principle they ought but in practice it is now clear that, if one water authority were acutely short of water, 'public opinion' would expect neighbouring water authorities to come to its assistance even where the shortage was due to its deliberate decision to adopt lower reliability standards. To an economist, the neighbouring water authorities would then be entitled to make extremely high charges for the water they supplied, but unfortunately it would not look that way to the public. Hence this is another area in which it may be difficult to delegate decision making entirely.

Control of Demand

Consistent with the individualistic philosophy outlined earlier, the simplest way to 'control' demand would be to charge for the water services by volume and to let people decide for themselves which uses of water were worthwhile and which were wasteful. The appropriate charge would be what the water costs (including an adequate return on capital) because it cannot help the community in the long run either

(a) to supply a cheap quota of water for prescribed purposes, or

(b) to charge a penal rate for purposes which are thought to be wasteful.

The popular idea of a cheap quota of water for certain purposes is precisely equivalent to a bounty distributed by water authorities under guidelines which would inevitably cause debate. For example, why should a young couple out at work attract the same bounty as an old couple using all their water at home, and would the bounty depend on the number of 'residents' (however defined)? If someone preferred to use his cheap ration to wash his car instead of bathing his children, who would stop him? If industry qualified, how would new or expanding firms be treated in relation to existing firms?

Nor does it make sense to charge a penal rate if this, for example, encourages consumers to spend more on saving water than it would have cost to supply the water. The whole purpose of equating charges to long-run marginal cost (so far as this can be established) is that it provides measured consumers with the correct incentive to save that water which is worth less to them than it really costs. Similarly, the measurement of household supplies only makes sense in economic terms if the value of the water saved is greater than the cost of measurement (which appears extremely doubtful except perhaps for new households and/or for garden use).

Where supplies are measured, exhortations to economise in the use of water should usually be unnecessary. For unmeasured supplies, it may be that regulations and/or exhortations are a more economical method of saving water than more meters. The interesting question then is whether such regulations to control demand should be applied all the time (by encouraging dual-flush cisterns, spray taps, showers, etc) or whether it might be more effective to seek much greater economies in the periods when water is really short.

Incidentally, instead of using an all-in charge of, say, 20 pence per cubic metre, it can be argued that a cost-reflecting tariff would be more on the lines of 10 pence per cubic metre (reflecting incremental running costs for 95% of the time) plus £2 per cubic metre over periods when the system was under strain (reflecting peak load costs for 5% of the time). These figures (for supply and disposal) are purely illustrative, but the principle is important.

Inter-Regional Schemes

As indicated above, the present system of ten autonomous water authorities has much to commend it. Most authorities are linking their inherited systems within their regions (where these links are economic and do not exist already) and the interesting question is why those links should not also be extended between water authorities.

In some cases this may not be worthwhile because of natural boundaries, or quality constraints, but it would be unfortunate if the zeal of water authorities to manage their own affairs blinded them to the possibility of importing water more economically from a neighbouring authority - quite possibly under a 'bridging contract' which might share the output of a large new scheme in its early years.

The recent White Paper (10) suggests that the proposed national water strategy should "compare and recommend, as a consequence of selected policies in resource development, major schemes serving inter-regional needs." This could be helpful to all concerned if, for example, it stimulated an informed debate of all the alternatives available (including that of doing nothing) but precedents in other public utilities do not suggest that any major scheme enforced on unwilling participants is likely to be successful.

By way of example, the gas boards were criticised by the Select Committee on Nationalised Industries in 1961 for failing to band together to build a massive Lurgi plant to supply a national grid. The gas boards were willing to co-operate shortly afterwards in the Canvey gas import scheme and it is now obvious that a decision to have built the Lurgi plant would have been disastrous. In short, if (and only if) a shared scheme really is more economical than a number of separate schemes there should be a way of bribing everyone to take part.

CONCLUSIONS

Policies for the Present

Having accepted the title of "possible policies for the future", it now seems more important to suggest a few policies for the present. It goes without saying that these represent the views of the author alone, and are not necessarily those of the National Water Council or anyone else in the water industry.

If present policies are to be rationalised:

(a) the accounting profession needs to agree on a system of current cost accounting which will help decision taking and enforce financial discipline;

(b) the Treasury needs to prescribe a realistic discount rate for economic appraisal which is reasonably consistent with the financial objectives set for the water industry (and allowed by the Price Commission); and

(c) the more extreme representatives of the environmental movement need to be convinced that this country has already made steady progress in cleaning up the environment and needs to choose its future priorities with care.

If these primary constraints can be clarified as above, water authorities should then be in a strong position:

(i) to preserve the continued wholesomeness of potable water supplies, paying particular attention to the quality of water supply rivers, and to improve the reliability of water supplies where necessary;

(ii) to meet the genuine needs of new development (households and industry) and to consider economical methods of meeting any increase in demand from existing consumers;

(iii) to investigate the condition of existing sewers, mains and other works in order to determine priorities for maintenance and for replacement; and

(iv) to consult local interests in order to determine quality objectives for inland waters and tidal waters (and a tentative timetable for achieving these objectives).

Whether or not the organisation of the industry develops further, it is likely that water authorities will have to decide between these priorities for themselves in the light of local circumstances. However, it is also to be expected that they will work out common policies wherever appropriate in co-operation with the National Water Council and the Department of the Environment, with the advice of the Water Research Centre (and the Central Water Planning Unit) where necessary.

Possible Policies for the Future

The future, as always, is uncertain and it remains to be seen if and when a National Water Authority is created on the lines of the White Paper referred to above. The stated aim of the White Paper is to establish three clear tiers of responsibility in England:

> "the regional water authorities, who will retain their executive responsibilities but whose planning will be guided by national strategic objectives; the NWA, which will be responsible for national planning; and the Government, to whom the industry as a whole remains accountable."

Within this structure it will be of crucial importance to be clear who is responsible for what. It will also be important for the national water strategy to be confined to those policies which need to be considered at national level, and able to be updated in the light of changing circumstances.

Subject to these provisos, there is every reason to hope that the engineers and scientists in the water industry, in co-operation with their financial and administrative colleagues, will achieve those ends (and only those ends) which their customers would be willing to pay for with their own money (individually or collectively) if they had the time to understand all the implications for themselves.

REFERENCES

1. Water Act 1973. HMSO.
2. Water Charges Act 1976. HMSO.
3. 1961, The Financial and economic obligations of the nationalised industries, Cmnd. 1337. HMSO.
4. 1967, Nationalised industries: a review of economic and financial objectives, Cmnd. 3437. HMSO.
5. Turvey,R. 1969, *Econ. Jour.*, June, Marginal cost.
6. Water Resources Board 1973, Water resources in England and Wales, vol.2. HMSO.
7. Walker, D.L. 1977, Financial obligations of public corporations. CIFIA annual conference, Eastbourne.
8. National Water Council 1977, February, Review of discharge consent conditions (consultation paper).
9. National Water Council 1977, *Water*, no. 14, Medical aspects of water quality (interview with Dr. Brendan Moore).
10. 1977, The water industry in England and Wales: the next steps, Cmnd. 6876. HMSO.
11. Accounting Standards Committee 1977, Accounting for depreciation (statement of standard accounting practice no. 12).
12. Management Accounting Unit 1973, Use of discounted cash flow and the Test Discount Rate in the public sector. HM Treasury.

DISCUSSION

Author's Introduction

MR. D.L. WALKER introduced his paper by showing a number of diagrams (Figs.1 to 4) which illustrated Tables I and II of the paper. Fig. 1 showed the effects of traditional accounting practice in the water industry: assuming stable price levels and an interest rate of 3 per cent, the effect of charging interest, I, and redemption, R, on an annuity basis was to match the pattern of financial charges to a constant physical output. Fig. 2 showed that, where this practice was modified by using straight-line depreciation, D, financial charges were no longer matched to physical output and that this would be exacerbated if a project took many years to build up to full output. In inflationary conditions interest rates were likely to be much higher, and Fig. 3 showed how 10 per cent interest resulted in an even greater disparity between financial charges and physical output. To make matters worse, if inflation continued at, say, 7 per cent per annum over the life of the project, the real value of financial charges declined very steeply and the disparity between financial charges and physical output became even more unreasonable. Although straight-line depreciation provided a prudent method of allowing for future increases in running costs or reductions in revenue, Table II showed how the overall effect could be excessively onerous in the early years of a project (and misleadingly cheap in the later years) during periods of inflation.

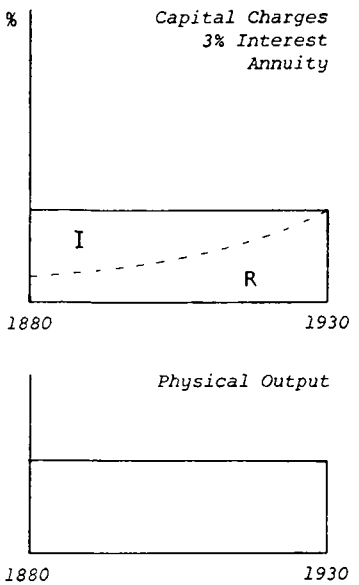

Fig. 1

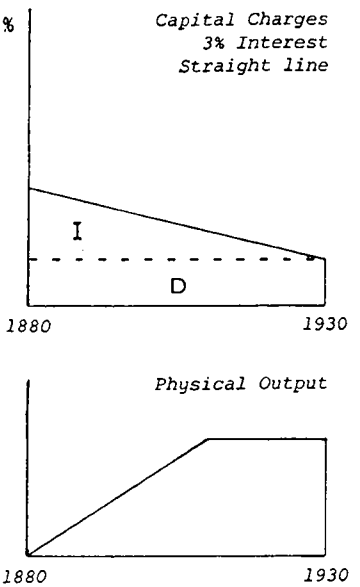

Fig. 2

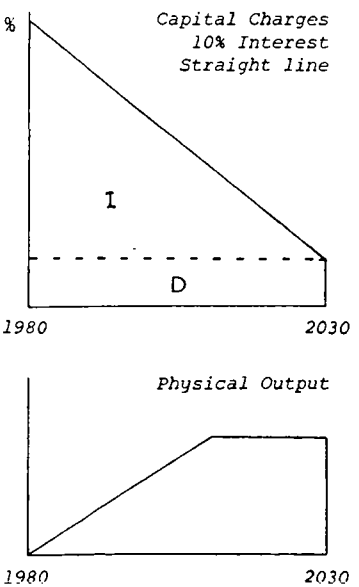

Fig. 3

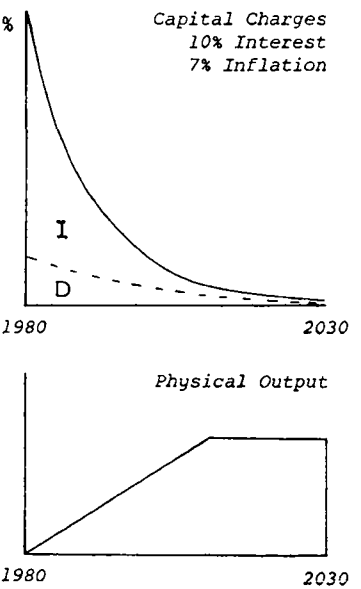

Fig. 4

He believed that two points made in Mr. Gilliland's paper (p.2 1) were particularly relevant to his own paper. Firstly, he agreed that depreciation was the mechanism by which the cost of the economic use of assets was charged in a revenue account before a surplus was declared and, secondly, he agreed that given a proper application of current cost accounting, with realistic depreciation on the current value of assets and a target rate of return on that value (say, 2½ per cent), then charges would approximate more nearly to current costs and probably to long run marginal costs.

Much of the discussion at the Symposium had, quite rightly, been directed towards obtaining a fair balance between the present generation of consumers and future generations of consumers. This was a function the Test Discount Rate was intended to perform, by guiding the choice and timing of investment and the level of prices needed to earn that rate of return on new investment. Although he agreed with much of Mr. Herrington's paper (p.6 1), he had never understood the distinction between the social opportunity cost of capital and the time preference rate. After allowing for the effects of taxation, differences in risk, and the margin required by financial intermediaries, he still believed that a rate of return should exist which would balance the flow of savings from one group of people (and firms) with the stream of investment by another group of people (and firms). That rate of return would appear to represent both the time preference rate and the opportunity cost of capital.

His own paper was essentially concerned with the determination of "true" costs and therefore of prices, and with decision-taking for investment in the water services. He agreed with earlier contributors that a rational approach to either problem required some agreement on what constituted a fair return on capital to be charged to consumers and (hopefully) credited to savers.

Verbal Discussion

MR. L. PHILLIPS (Northumbrian Water Authority), in opening the discussion, said that under the section 'Definition of Terms' (p.7 4) there was a reference to the value of an asset being equal to future net earnings. The computation of that value could present major difficulties as far as the water authorities were concerned as there were some assets which would continue in use virtually for ever. There was a further comment that net earnings were equal to the difference between revenue and operating cost. This economic concept was really more related to company finance where assets were used for earning profits, rather than water authorities who were merely concerned with recovering costs from their customers. The matter was also complicated by the fact that different authorities adopted different tariff policies which, using this basis, could create a situation in which exactly similar assets could be accorded different values. Care would also need to be applied in coping with Government restrictions on pricing policies of nationalized industries.

Under the heading 'Illustrative Example' paragraph (b) (p.7 7), there would certainly be some difficulties in computation with an asset such as a major dam which could presumably last for several hundred years. In the same way, many of the sewers in the ground which were made up of ceramic pipes would last virtually as long as the ground surrounding them remained stable.

Paragraph (c) (p.7 7) referred to capitalizing interest after commissioning. In this context, it might be as well to remember that few authorities capitalized interest during construction and none, so far as he knew, did this exercise after commissioning.

The effects of inflation and ways to deal with it were considered (pp.7 7 & 8). In his view, the tables were too restricted as they referred to only one asset and would consequently only be relevant in the context of a single asset company, e.g. a quarrying organization. With water authorities, there was a rolling programme of work year by year, and many of the difficulties referred to were automatically covered by the rolling programme being carried out at prices which ruled at the time when construction took place. On the other hand, if approximations were made on particular interest rates, either fixed or index-linked, it became very complicated indeed to carry out the exercise according to the author's tables and could give rise to a plethora of money being raised (p.7 9).

Several of these points were related to the matter of depreciation which in the present context was one which must be viewed with a clear mind. It should be stressed that depreciation charges in accounting conventions were the writing-off of the cost of an asset over its useful life. This meant that the actual charge was limited to the writing-off of the actual historical cost. In times of inflation, the need for other items to be retained out of the current revenue became evident. These additional requirements might be for the provision of funds to finance the replacement of worn out assets without raising additional borrowing; or to reflect a cost message in terms of correct prices; or to provide funds for repayment of loans over periods of years shorter than the useful lives of assets. Each of these items could be justified on grounds of good financial policy, but it was necessary to keep it well in mind that the decision to make these further provisions was a matter of policy, not a matter of cost. In terms of company finance, the decision to make these additional "depreciation" provisions was an alternative to raising additional capital either on the open market or from existing shareholders. In terms of water authority finance, whilst the practice was, in reasonable moderation, fully justified to maintain economic viability, it always amounted in some degree to making charges to present consumers to meet future consumers' liabilities. In this context, it was also relevant to bear in mind that if additional charges were to be made under the heading of "depreciation", credit should be taken for the reduction in real value of the borrowings made to finance the installation of the assets in the first place. (In the Hyde proposals, this item appeared under the Gearing Adjustments).

He made the following comments on the section entitled 'Conclusions' (p. 7 14):

1. Charges must be acceptable and reasonably easily explicable to consumers and such that authority members, both industrial and political, found them to be reasonable.

2. In considering two-part tariffs, two possible approaches might be taken: one being on the basis of fixed and variable charges, and the other on the author's private and social goods.

3. Where activities of undertakings in EEC countries were constrained by Directives of the Commission, consideration should be given to the Commission finding the funds, either in whole or in part, necessary to meet their strictures.

4. In so far as decisions on policies of water authorities etc. were laid down by the Government, e.g. social goods, consideration should be given to some of the cost being met from national taxation, which was socially regulated, rather than from cost-justified charging arrangements.

In the same way, if the Government restricted by edict the level of charges in carrying out, say, an anti-inflation policy, consumers should be charged with the difference between the charges properly arrived at and those which the Government allowed.

5. Whilst a proper system of current cost accounting was appropriate for economic appraisals, it was not absolutely essential for pricing policy. It became relevant for pricing policy only in light of the decisions referred to under depreciation (see above). In this connection, it was as well to remember that water authorities operated in an area where there was no competition for their services, and it was incumbent upon them to ensure that they always maintained a proper balance between the costs properly allocated to present-day consumers against the liabilities properly due against future consumers.

MR. E.H. NICOLL (Scottish Development Department) said that the water industry in Scotland was organized differently from that in England and Wales, in that it was not a quasi-nationalized industry. Despite this, many of the problems discussed by the author were also exercising minds north of the border. In the introduction to the paper, the distinction between 'private goods' and 'social goods' was illuminating. In Scotland, water supply was more social than private. He agreed with the author that there was a need to soften the economists' tendency to regard water services as private goods. In the fields of water supply, sewage disposal, and river pollution, social judgements did have to be made by engineers and scientists for the common good to cover standards appropriate to such matters as public health and amenity. In this context, he asked the author to comment on the Daymond judgement.

While thinking about 'social goods', he referred to the part of the paper which dealt with river quality objectives and the point (p.7 3) that a collective decision was needed on the overall objective to be adopted. In this connection, would the author consider whether high standards of sewage treatment were necessary below water supply intakes on rivers? Should lower quality objectives be contemplated for these sections of rivers, set, perhaps, in order to avoid nuisance or risks to public health arising from their use for the disposal of sewage or trade effluent? How might an industrialist view a local body's decision which was based on recreation, amenity, aesthetics, or local pride (p.7 11)?

Moving on to marginal costs, the author did not fall into the trap of thinking in terms of a single "reliable yield". This would be misleading as works were capable of several outputs of varying reliability. The consumer was vitally concerned with reliability of supplies at the tap. The consumer wanted water at the right place, at the right time, in the right quantity, and at the right price. Did the author think that water authorities should make social judgements, for example, by flogging their sources to produce more water for most of the time, since sufficient rain fell in most years, thereby saving money but necessitating more frequent and intense restrictions as reliability was progressively reduced?

Would not the basing of charges on long run marginal cost (p.7 6) result in a profit if charged over the period before a threshold on investment was reached? Was this acceptable to the water industry? A similar point would appear to arise (p.7 8) where the charging of depreciation at current price levels on historical assets would lead to a profit and generate more income than was needed to finance new investment.

With regard to the writing-off of a project over its useful life [p.7 7, para.(b)], how was this assessed for projects with indefinite lives, for ex-

ample, dams and tunnels?

With final reference to marginal costs, could the author explain the definition of marginal cost (p.7 5) in words which a layman could comprehend? Could the author perhaps illustrate the answer with a simple numerical example?

Referring to the conclusions and in particular to 'the need to preserve the continued wholesomeness of potable water supplies' [p.7 15, para.(i)], did the author consider that it would still be right in the future to continue to purify all water to a high standard and distribute it in one system? Also, with respect to 'the economics of meeting the needs of new development' [p.7 15, para. (ii)] having regard to the vast anounts which were spent on the provision of sewers each year, would the author not agree that the choice and design of a sewerage system which was to be adopted was a matter of policy which required the most careful consideration? The need for this had been pointed out in a recently published report by a Working Party on Storm Sewage, of which he himself had been Chairman. The Working Party was not convinced that the separate system was the universal panacea: at best, this was not proven. The separate system had the hazard of wrong connections; there was the pollution from surface runoff which was now the subject of study in a number of countries, and in many cases there would be a clear financial advantage in adopting the combined system with storm tanks incorporated to give protection to streams where special circumstances required this. Clearly, policy decisions on this matter would also be germane to the author's point [p.7 15, para,(iii)] where he raised the question of determining priorities for the replacement of exisiting assets, a matter which was now of considerable import to the water industry.

MR. J.E. THACKRAY (Severn-Trent Water Authority) said that the author's diagrammatic presentation of financial analyses illustrated quite dramatically the way in which a change in accounting systems in the water industry from "loan charge accounting" to " depreciation accounting" had affected the ways in which the use of assets was paid for. The position had been highlighted and exacerbated by the effects of inflation. The author's tables, and the illustrations used in his introduction of the paper (p.7 17), referred to single, large schemes. He wondered whether the author had had the opportunity to construct similar tables, dealing with a rolling programme of schemes, and what would be the effects of a rolling programme and inflation on the depreciation provision in the two methods of accounting. These issues were particularly important as the industry was contemplating the prospect of yet another major accounting change to a current cost basis, and the best ways of calculating depreciation had yet to be agreed. The principal alternatives were to relate depreciation to the rolling average of actual renewals investments, or to calculate the theoretical combination of average asset lives and their national current values.

He deplored the view that water was particularly "cheap". The price might be right or wrong, but he personally paid about £90 per annum for total water services and this was marginally more than he paid for electricity, and similar to the charge for the telephone and about one-half the charge he paid for gas. None of these sums did he consider to be"cheap". The argument conducted by the author and by Mr. Herrington (p.6 5) on discount rates was particularly interesting, and the concept that the Social Time Preference Rate might in some circumstances be negative was one he found particularly intriguing. For a long time he had been of the view that jam today was always better than jam tomorrow. Recently his view had changed with the realization of the obvious fact that most people would prefer some jam every day and did not want it all today or all tomorrow. Working through this concept might form a link between the conventional economist's view of the world and the view of some engineers and most conservationists: that was that total consumption was what

mattered and there was little respect for the time in which it took place.

MR. D. WATSON (Central Water Planning Unit) said that because he sensed a credibility gap opening between engineers, he would ask the author for clarification of the 'Definition of Terms' (p.7 4). Paragraphs (a) and (d) were two independent definitions of the same thing, i.e. the net value of an asset at a point in time. Definition (a) could be derived from estimates of future asset life and future charges, taking account of inflation and costs or marginal costs in some circuitous, iterative process. Definition (d) was more backward-looking containing past depreciation: but future value depended on future charges and not what had been written-off capital in the past. The two definitions could not give the same answer except where past depreciation had exactly equalled earnings, and initial value was a continuous variable assessed as in (a). Definition (a) appeared as the truism with definition (d) appearing to be superfluous. Net value would inevitable be re-assessed from time to time as knowledge of asset condition became available from inspections, and an initial assessment of gross value would be unlikely to perceive these variations.

There was also something odd about definitions (e) and (f). The overall relationship at (f) gave the ratio of residual net earnings after depreciation to future net earnings. For this ratio to represent return on capital that had been employed, future net earnings must equal capital already employed. This could hardly be so.

The author's equations depended very much on depreciation, a concept which was worrying. Depreciation was said to be "written off" assets, yet in business enterprises, retentions were quickly written back in again, often by spending on capital assets. Capital employed then became initial capital plus accumulated re-invested depreciation.

These conceptual difficulties could be faced more easily if it was certain that the industry would, as time passed by, actually replace all its present assets in a similar form; but works were abandoned, small reservoirs were drowned by large ones, industry and people changed locations, and land was redeveloped differently. When the task of forecasting these changes and inflation was added to that of evaluating asset values and marginal costs as a basis for future charging policies, then charges could be quite variable.

Economists generally considered water supply charges to be too low when based on historic and not forward-looking costs. Historic costs were "too low" because assets whose loans had been repaid were still in use at no charge. The water industry "wrote off" its assets long before their useful life was over, under compulsion from lenders requiring loan lives to be shorter than asset lives. As loan charges were equivalent to depreciation, this meant that the industry was already charging too much depreciation. Where then was the case for more? It also meant that during times of expansion, charges were not as low as economists thought. A more equitable solution was the old idea of extending loan lives, and leaving forward-looking charges as a separate issue.

MR. E.C. REED (Thames Water Authority) referred to the author's section on the concepts of private and social goods. It was his experience that market traders sought not only to cover costs but, in addition, to charge what customers were prepared to pay. In the commercial world where benefits derived from water supply might be out of all proportion to the quantity supplied, it was evident that there was not a tendency for present charging levels to drive custom elsewhere. In this sector proposals to charge by volume thus represented a move away from the concept of treating water services as 'private goods'.

Throughout the papers presented to the Symposium there was an underlying current of feeling for metering. One speaker had suggested that he might be concerned about the problems of installing the massive number of meters required in the London area. It was not this point that concerned him however; it was rather the Director of Finance's problems regarding the financing of the provision, installation, and administration of metering.

Regarding inter-regional projects, new legislation had come into being in 1963 and emphasis came to be placed on the disadvantages of constructing larges schemes which were not utilized immediately. Despite the virtue of this argument, such schemes continued to materialize: this was an aspect which needed to be looked at carefully, particularly in relation to the provision of large, expensive, trunk transfer schemes, as opposed to local inter-linking of distribution systems.

Author's Reply to the Discussion

MR. D.L. WALKER recognized that the definitions of terms on p.7 4 had been over-condensed. Depreciation was always a controversial subject: Mr. Phillips was concerned with writing off the cost of an asset over its useful life, but other accountants were more concerned with changes in asset values. He himself believed that his definitions were consistent with the following definition by the Accounting Standards Committee (11):

> 'Depreciation - the measure of the wearing out, consumption or other loss of value of a fixed asset, whether arising from use, effluxion of time or obsolescence through technology and market changes.'

Mr. Phillips had very reasonably pointed out the differences between water authorities and industrial companies but one of the themes of the Government White Papers (3) and (4) was that public enterprises ought to earn a return on capital which was comparable with that earned by large industrial enterprises. He did not share Mr. Phillip's view that "cost" meant historic cost but he agreed that where the cost of capital worked out less than the prescribed rate of return it would be difficult to keep a fair balance between present and future consumers. He felt sure that Mr. Phillips did not really believe that a "crock of gold" existed in Brussels or in Whitehall to meet the cost of socially-desirable objectives, but he agreed that anyone who set unreasonable objectives ought to be asked to pay.

The author's definitions rested on the belief that it was necessary to formulate a consistent model for the ideal world before seeking to understand the problems of the real world. In an economically ideal system of water services the timing of individual projects would be chosen so as to equate the present value of future net earnings (at the appropriate discount rate) with their capital cost. If the PV of future earnings was greater than their capital cost the project should have been started earlier, and if it was less than the capital cost the project should be deferred. Thus definitions (a) and (d) on p.7 4 were not independent, as Mr. Watson had suggested, and Table I was intended to demonstrate their interdependence. He agreed with Mr. Watson that it should be part of any accounting system to re-assess net asset values from time to time: writing assets up or down in this way would help to deal with the unpredictably long lives mentioned by several contributors. Definitions (e) and (f) could be reconciled if historic asset values were scaled up in proportion to inflation, consistent with Table II. There was no need for capital employed to equal initial capital plus re-invested depreciation: neither did conserv-

ative asset lives necessarily compensate for inflation. If a water authority used a number of assets having a life of 50 years (built at various times), increased depreciation in, say, years 1 to 25 would be offset by reduced depreciation in respect of, say, years 26 to 50 of earlier projects.

Mr. Phillips and Mr. Thackray had suggested that the effect of adding together the capital charges on a rolling programme of schemes might reconcile method (a) and method (b) of Table II. However, he had not suggested that total capital charges were necessarily too low. On p.7 8, his concern had been with the distortions which present accounting practice would create between areas and between time periods, and he believed that Mr. Phillips and Mr. Thackray were both familiar with practical problems of this nature.

Mr. Nicoll's questions were more down to earth. The author accepted the principles which underlay the Daymond judgement but recognized that the variety of circumstances which existed in relation to septic tanks and cess-pools and surface water drainage meant that sewerage was a difficult service to cost to individual users. His view was that the improvement of industrial rivers was much less important than the quality of potable water supplies. Where higher standards were really worthwhile the "polluter pays" principle required that industry should either put up the price of its product, move elsewhere, or give up. The illustration of long run marginal cost deserved another paper but in essence the principle was that prices charged should not fluctuate abruptly in real terms and should be sufficient to earn an adequate real return over the life of the project - just like the Water Resources Board's concept of "discounted unit costs" (6). Although the possibility of dual supplies of high and low quality water should not be overlooked, he doubted whether they would be economic and pointed out the quality problems which might arise from longer retention times in potable supply pipes. He welcomed the report of the Scottish Working Party on Storm Sewage and recognized that separate sewers were not a universal panacea, although he still believed that the problems arising from combined sewers were usually even worse.

In reply to Mr. Reed, he said that traders in an effective market could not charge prices much in excess of costs (including a normal return on capital and on their own time) because excess profits drew in new competitors. It was only monopolists who were able to derive excess profits from the sale of 'private goods', and they were often constrained by Government measures, e.g. laws against undue discrimination by public utilities.

He concluded by thanking Mr. Thackray for his perceptive comments on the Test Discount Rate. He readily agreed that it was naïve to explain the Test Discount Rate by asserting that ' jam today is worth more than jam tomorrow' (12) and that most people would prefer some jam every day and did not want it all today or all tomorrow. That was why he would welcome a test discount rate much lower than 10 per cent in real terms and much more consistently applied throughout the public sector.

SUMMING UP THE SYMPOSIUM

MR. K.F. ROBERTS, BSc, FICE (*Vice-President*)* recalled the President's anxiety, almost a year ago, concerning the manner in which individual subjects in this Symposium would blend. It was one thing to have an idea on the main theme but, understandably, uncertainty crept into the minds of those responsible when it came to seeing how authors would produce material which would fit into the overall plan. Without fear of dissent from the delegates, he felt that the President's concern was unfounded. They were indebted to the President for selecting such an interesting and challenging range of papers which had been so well matched.

Fortunately, the President, in inviting him to sum-up the Proceedings, had granted him licence to throw in some personal reactions and to refer to issues which might have been overlooked or "glossed over" during the presentation of the papers, as well as to bring out the main issues which had emerged during the Symposium. If he was to react, he did so in respect of his experience with one West Country authority and he did not necessarily speak on behalf of his colleague chief executives. To start with, therefore, he presented himself as a Chief Executive from a West Country "market place", to use a phrase which emerged during discussions.

His first reaction was to draw on Lord Nugent's opening remarks in which he made the point that the new water industry was well established in a pioneering effort in comprehensive planning which was not previously known in the water industry. Lord Nugent had then said that 'strands are coming together at regional levels with a large measure of judgement'. It was the word 'judgement' which stood out in the mind. Care must be taken in these early days of the new industry not to be misled into thinking that by using a wide range of economic appraisal techniques, a form of exact science was being built into planning.

Planning involved a lot of judgement, perhaps more than was liked at this stage of the game, and therefore a balance was needed between techniques and judgement. He suggested that although there had been much sophisticated thinking in the course of the Symposium, planning would never be just a series of calculations or tables or graphs. To put it very simply, what was being attempted was to anticipate the road ahead when objectives had been defined, and there was a need to know the options that were open. All available help was needed to find the most advantageous way through the "jungle" which lay ahead, in the best interests of the consumer and public that the industry served. He was sure that this initial point would be understood by the "academics". What he had tried to do was to instil the need for a sense of balance in delegates' minds at this early stage in the summary.

Now he came to the main issues which he thought had emerged during the course of the Symposium. First of all, Mr. J.E. Thackray's paper which set the scene and framework within which planning was carried out had helped greatly. The author had left no doubt about the high capital intensity of the industry, and he was interested in his analogy between choosing planning options and the considerations which had to be faced when making a journey, e.g. whether

* Chief Executive, Wessex Water Authority

the journey was necessary or whether it should be made by road or other means: but he thought that the author had left out a thought which crossed his own mind, namely "I would prefer not to start my journey from here". Could not the same be said in a planning sense, because much of the water industry's inheritance was not to the industry's liking?

It came through clearly from many speakers that demand forecasting and data was an essential activity which required much further study. Indeed, he liked Mr. R.C. Steiner's remarks when he said that he was 'looking for the truth' (p.1 34). He wondered whether Mr. Steiner was implying that the truth and data were not related. That might not be far from the mark and he therefore asked how much attention had been given to the reliability of the data on which there was current planning. It was his personal experience that some of it was rather doubtful and decisions involving large capital might be made on the wrong assumptions.

He referred to a small district within the Wessex area where recent improvements in the metering and measurement of the flows in the mains had revealed a reduction of one-third in the consumption figures. He asked delegates to think of the resources which might have been written into the Authority's plan to meet future deficiencies which might never arise.

To show that care must be taken with data, he recalled Mr. J.E. Thackray saying that in one of his projections, the trend was either veering to zero or to infinity. It was highly likely that Mr. Thackray would find a suitable figure between these two values!

His next point related to the uses of water. It was essential that this matter should be researched into much more and the work undertaken so far under Mr. Thackray's guidance was most interesting. More should be done in this direction.

The next issue which he felt was evident throughout the discussion was the confusion which would arise until better charging and borrowing policies could be established. Indeed, until these issues had been resolved, planning would suffer. He recalled one contributor saying that water was'too cheap' and this was echoed by Mr. E.J. Gilliland (p.2 1). Coupled with this, there was the problem that in the current economic climate, the consumer and public at large were conditioned to think of increases in charges on a percentage basis, comparing one year with another. If, therefore, there was a charge which was too low, the opportunity of bringing it to a correct level, without incurring considerable wrath from consumers and politicians, seemed highly unlikely. However, some charging policies must be established which were accepted by all concerned because delegates had heard during the Symposium of a case where, even if no further capital schemes were embarked upon, charges would still multiply considerably within the next few years.

However, the political impact of charging could not be disregarded and he reflected on the fact that in presenting the Medium Term Plan to the members of his own Authority, strong feelings were not shown at the magnitude of increases in charges which would result in the next five years. However, emotions ran high when the figures came forward as a hard fact in relation to the first of those five years, namely the next year's charges.

Another important point made by Mr. E.C.Reed (p.2 16) concerned the credibility of the industry in the public eye, and it was most important that plans

should be realistic and achievable in the time scales quoted, otherwise the confidence of the public would be lost.

On the subject of renewals, it was obvious that many more facts were needed before judgements could be made on this subject because there was a risk that, in an arbitrary way, too many resources might be committed to this heading. Mr. J.D. Perret made a point (p.1 32) which he himself had personally overlooked: namely, that by basing renewals on past capital expenditure trends, there was the possibility that this included previous renewal costs.

He next made a plea to all the financial experts and economists to get together quickly and resolve the technical details concerning appraisal techniques, rather than to debate them in public at a Symposium like this. He hastened to add that if engineers argued over the strength of materials used in their designs or the technical basis of their calculations, they would be given the reception they would deserve at an Institution Symposium. Surely, it was not impossible to have some large measure of agreement on such professional issues so that techniques could be applied universally without too much argment that might militate against the benefits which could be derived.

There was a point made by Mr. P.R. Herrington (p.6 1) with which he entirely agreed, and it was the statement concerning wastage or leakage of water. He nailed his flag to that mast. This was an important first option in planning and one which should be rigorously followed with a view to reducing the quantity of water which failed to reach the consumers' taps.

He noted Mr. W.J.F. Ray's comments (p.6 28) about the figure for loss which was considered reasonable but from his own experience, he thought a figure higher than 15 per cent applied in many rural areas.

He liked the words 'unaccounted for water' instead of leakage because this brought home the need to adopt a mental attitude of accountability for leakage. He stressed that this was an important first option, and more work should be done on this together with the Water Research Centre who, based on Mr. V.K. Collinge's contribution (p.3 21), wished to make a major contribution to the industry's good. This was a field in which their greater involvement would be invaluable.

It was important to spend more time considering what were the standards of service that should be provided and he agreed with Mr. Thackray that the trend seemed to be that the consumer wanted 'jam all the time'. He was not too keen on the idea proposed by Mr. P.R. Herrington (p.6 29) that it might be a good thing to have a drought every few years, if only to make people conscious of the need for water economy. His own experience was that it was one thing to talk of a lower standard of service when water was plentiful, but there was no doubt that the public and the media would have little time for the water industry if it was not geared to meet demands during long dry spells.

Mr. H. Fish had brought his usual and expected lively presentation (p.3 16) to the proceedings and delivered a most masterly speech. He had emphasized his thinking that abstraction from the lower end of rivers would also promote environmental improvement in the river system. There were major downstream abstractions from the river Severn, but judging by the exchange between Mr. Toms (p.3 23) and Mr. Young (p.3 19), the philosophy outlined by Mr. Fish still remained a dream.

However, what did emerge was the urgent need to investigate the medical aspect of the quality of water abstracted from the lower reaches of major rivers in order to allay public concern. Some scares had been raised which were based on limited knowledge, but until clear medical evidence pronounced on these issues, there would be a continual unease on the part of the consumers in the extended use of river waters for public water supply.

On another matter raised by Mr. Fish, he supported his plea to show caution in the transfer of water from upland chalk acquifers for distant areas of demand. In the case of his own Authority, there had been similar problems in the Dorset area where the local inhabitants were totally opposed to abstraction from the upper reaches of the chalk area because of the anticipated impact on the "water-bournes": but they were entirely in support of proposals to abstract underground water from the coastal belt.

An item which he felt was important but which was overlooked in the main presentations was that raised by Mr. G. Cole (p.2 18) concerning manpower in relation to planning. This should be incorporated in all plans because some capital works did involve a reduction in labour by the use of automation, or the works involved an increase in manpower in terms of maintenance. Manpower was an emotive issue and the "head count" was something that had to be lived with, but the economics of capital works and manpower could not be considered separately. Also, the timing and phasing of manpower changes and the development of new works were bound together in relation to revenue expenditure. The way to answer "head count" critics was to have manpower linked to the plans for all to see.

There was a tendency in the papers to overlook the fact that the new Water Authorities were still in the very early stages of development and certain restraints associated with that fact were omitted. For example, many of the county councils had not yet produced their structure plans and, therefore, water authorities could only guess at this stage on their impact on the medium term plans. Furthermore, the fact that the sewerage function was vested with district councils made it extremely difficult to assess, with the accuracy one should, the content of the capital programme being submitted by them. This was another restraint which would have to be resolved at some time in the future.

Another issue which was not perhaps adequately covered in the papers concerned the possibility of Department of the Environment interference with the plans of the Authorities, not to mention the advent of the National Water Authority whenever it arose. Indeed, it was the recent White Paper which had brought this issue in sharper focus. However, he hastened to add that these remarks were to be taken as implying that there would be any direct restraint by these important bodies, nor was he suggesting that the academic studies relating to economics and financial appraisal were not required. The Hetheringtons and Hankes of this world were needed. However, it was hoped that they would not mind if it was said to all who sought to interfere with water authority planning - "Please try to join us in keeping all feet firmly on the ground".

The contribution by Mr. B.M.U. Bennell (p.4 1) brought a touch of reality to the Symposium. At one minute advance techniques and practices on decision-taking were being considered and in the next, the enormous problems facing the developing countries were heard. It certainly brought a sense of proportion to the discussion. Perhaps an important point which had emerged in the discussion

related to the public health aspect of the problems of the developing countries, and it was one which should not make people overlook the fortunate inheritance they had in this respect in the water supply of this country. Surely the lesson to be learnt was that standards must not drop too low in this period of economic stringency in case public health was adversly affected.

We were he felt a world leader in the new water management philosophy. Surely the plea for help which was made by Mr. Bennell could not be ignored. He was encouraged that the National Water Council, and particularly its training division, and many Water Authorities were giving help and he felt sure that more could still be done.

The subject content of this Symposium, therefore, had been extremely well chosen and had been very timely. The thinking was right - it was early days as far as the water industry was concerned, and because of this, there were many restraints which had not been sought. Mr. P. McIntosh put it very well when he said (p.5 14) that the gap between theory and current practice was still wide. Because of this, he suggested that a further Symposium on the same lines would be most appropriate in a few years' time when it could be seen if that gap had narrowed.

The Symposium had illustrated a major evolution in the water industry. In a few years, it had moved from a fragmented business to a fully integrated and complex enterprise, which was one of the most capital intensive in the country, and the most sophisticated financial and economic thinking were being discussed at the Symposium.

It had crossed his mind to compare the subject content of the Symposium with that of winter meetings of the Institution a decade ago. He thought in those days that specialized technical subjects relating to pipelines, the design of structures etc., would have been heard. It was quite a change from the programme that had been faced in the two days of the Symposium. Indeed, the evolution in the industry had been reflected in the Institution's life. Horizons had been widened. External expertise had also been brought in to balance thinking. He believed that this indicated a very healthy attitude by the Institution and suggested that it showed that the Institution had a major part to play in the professional forward-thinking of the future. He hoped that the members would accept this challenge.