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ECONOMICS OF WATER RESOURCE MANAGEMENT

DRAFT FINAL REPORT

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VOLUME TWO - TECHNICAL REPORT

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EXECUTIVE SUMMARY

This is the technical volume accompanying the summary report for a project which aims to assess the potential role of market mechanisms in the allocation and development of water resources by the NRA. It includes a theoretical assessment of unit water pricing, setting out the rules and principles underlying efficient pricing structures and the ways in which these principles might be applied in practice. The advantages and potential problems involved in the introduction of tradeable permits are also evaluated. Evidence is presented on the value in use of water and the willingness of abstractors to pay for additional supplies or improved reliability. For the irrigation and industrial sectors the results from field investigations in the Anglian, Yorkshire and Severn Trent NRA regions are used to supplement the limited evidence available on value in use in the literature. A cost attribution methodology is developed to enable the NRA to more closely relate its water resource costs to the abstractor groups benefitting from the expenditure. Finally, the feasibility of introducing market mechanisms is evaluated in terms of the likely behavioural responses of the different abstractor groups.

Key Words

Water resource economics, value in use, cost allocation, incentive charging, tradeable permits, abstractor behaviour

1. OBJECTIVES, METHODOLOGY AND STRUCTURE

1.1 Terms of Reference

The overall project objective was to advise the NRA on how economic principles can be applied to its function of water resource management. Ideally, abstraction, waste water discharges and other 'in-situ' uses should be considered together within a holistic approach to management. However, our remit was to concentrate on the role of economic tools in the allocation of abstraction water and to inform decisions on investments in water resources augmentation, both to increase absolute supply availability and to improve reliability. Therefore, although the principles involved in waste discharge and 'in-situ' water pricing will be alluded to, there will be no detailed discussion of the specific problems and issues raised in developing charging schemes for these water uses. The potential value in use of supplies for in-situ purposes is, however, considered in this report.

Within the overall project objective, there were five specific tasks set in the terms of reference. These were:

(a) Review the 10 Regional abstraction charging schemes in operation in 1991 and the proposed National charging scheme. The review of the ten regional schemes was completed in 1991 and given in our first progress report. Since these schemes are now history no attempt to reproduce our conclusions is made here, rather attention is focussed on the National scheme.

(b) Evaluate the average and marginal value of water allocated to those users who abstract water from rivers or ground waters and those users who utilise water 'in the river'. It was recognised when developing the terms of reference for the project that the comprehensive construction of demand schedules, which ideally was necessary to calculate average and marginal use values, was beyond the scope of the study. Rather, a search of available literature would be made in an attempt to obtain some indicative information; the literature review would be supplemented by limited field investigations of agricultural and industrial abstractors.

(c) Evaluate the feasibility of using pricing policies to manage the demand for water. The theoretical advantages of employing economic instruments to help manage demands are well established. However, the feasibility of their use in practice depends upon three things. First, customer response to price; second, the costs and informational requirements needed to establish and implement an appropriate pricing system; and third, the specific objectives of the NRA and the Government.

Pricing is only one of the potential economic tools for allocating available supplies between users. The terms of reference were, therefore, extended to allow consideration of tradeable permits/marketable rights.

(d) Advice on ways in which abstraction charges could be structured to reflect NRA expenditure and the reliability of the resource to the abstractor. Under current legislation NRA charges can only be cost recovery. A methodology for allocating NRA costs between functions and water users has been developed as part of this project. However, abstraction charges based only on past NRA expenditure will not result in an optimal allocation of resources; water company investment in regulating reservoirs and potential investment by the NRA in flow augmentation must also be taken into account.

(e) Advice on how economic principles might be applied to defining 'reasonable needs', resource augmentation needs and lost opportunity costs. This objective in effect brings together all the parts of the research programme. In economic terms, reasonable needs can only be established from value in use, including the value of reliability. However, it is also possible to define 'reasonable needs' in terms of non-economic efficiency objectives, such as the protection of particular interest groups or communities, or the maintenance of environmental attributes deemed by the political process to be desirable. Decisions about whether resource augmentation should take place ideally should be based on three sets of information: user demand curves, augmentation costs and the opportunity costs of non-augmentation strategies. This last is particularly important where users or potential users have no effective price mechanism through which to express their willingness to pay for additional supplies. Where normal price-use relationships are absent lost opportunity costs are a fundamental component of value in use estimation. In the water resources case, the traditional assumption has been that available abstraction water for agricultural and industrial purposes was fixed unless growth in demand could 'ride on the back' of capacity extension schemes developed for municipal use. The 'first come, first served' system of allocating available supplies has inevitably imposed costs not only on those refused a licence, but also on the system as a whole by creating an inflexible sub-optimal resource allocation.

1.2 Methods and Methodology

1.2.1 Field Investigations

Some of the project objectives could be at least partially fulfilled by desk studies, utilising public available material and standard evaluation techniques. However, it was known that very little data existed for Britain on the value of water or on user response to economic instruments. Moreover, virtually nothing had been published on the value abstractors placed on reliability or on the opportunity costs imposed by the 'first come, first served' water right allocation system.

Therefore, it was proposed to undertake a limited programme of field investigations which was primarily designed to:

- obtain some up to date insights into the value of abstraction water for industrial and agricultural purposes.
- gauge the likely actual response of abstractors to incentive pricing and tradeable permits and investigate any constraints operating to limit their ability to respond to economic signals in a prescribably rational manner.
- assess the likely consequences of a more economically efficient resource allocation.
- obtain some indications of abstractor willingness to pay for reliability.
- investigate the opportunity costs imposed on both existing and potential abstractors by the current rights allocation system.

It was never the intention to obtain data on these subjects which would be representative for the country as a whole; this would have necessitated a very major survey programme, far beyond the scope of this project. Rather, it was hoped to provide some indicative information.

It was planned originally to concentrate the field investigation on four over-abstracted catchments, chosen in consultation with the NRA. This strategy would, it was thought, have the best chance of providing data on the losses incurred by abstractors in areas with poor reliability, the risk avoidance expenditure made, and any unsatisfied demands for supplies. However, the programmed work was subsequently amended and studies were undertaken in only two over-abstracted catchments, namely the Cam and Rhee (Anglian Region) and the Colne (Yorkshire Region). There were two basic reasons for this. First, the other catchments offered by the NRA regions for study did not contain users with sufficiently different characteristics to allow coverage of all categories of abstractor in particular virtually no industrial abstractors were included. Second, it rapidly became evident that an attempt to investigate the latent demand for abstraction in such catchments would not be possible, except for any unsatisfied requirements of existing licence holders. No NRA region apparently kept records of requests for licences which were rejected before formal applications were made; as most rejections occurred at this informal stage there was no database from which to survey enterprises with unfulfilled demands to establish the costs incurred in obtaining an alternative water supply.

The decision was, therefore, made to replace two of the catchment studies with alternative field surveys. The first of these was specifically directed at industrial users and was conducted in the Severn Trent region. It covered all those firms which abstracted supplies from the canal system operated by the British Waterways Board, with the Board holding the NRA abstraction licence and selling supplies to the end user under contract. As explained in 4.3, this group of firms was chosen primarily because of the BWB's reported use of 'what the market will bear' prices, based on an NRA costs plus charging formula; notionally then demand over a greater range of price points could be investigated. In addition, the generally more reliable nature of canal supplies might allow some insights to be gained on the price industrialists were willing to pay for improved security.

The second alternative study was undertaken to take advantage of data contained in the NRA Anglian region's computerised abstraction files on irrigators who had invested in on-farm storage facilities. The level of expenditure made on alternatives to direct water abstraction at the time of irrigation need would provide some indication of the willingness to pay for reliability and of the implied value in use of water. Some farmers with storage would have emerged from surveys in the over-abstracted catchments but a more systematic analysis could be undertaken by establishing two samples: one of farm businesses with storage and a second 'shadow' set of concerns without such facilities.

Three additions were also made to the originally proposed programme of empirical work. First, a small scale survey of land/estate agents was conducted in Birmingham and the Anglian region in an attempt to establish whether the existence of an abstraction licence created additional land or property value. Second, a telephone survey was undertaken of a sample of businesses holding completely un-utilized licences to establish why the licences were retained and what incentives could best serve to pursuade firms to relinquish their water rights. Finally, a very small study was undertaken of fish farmers, utilizing the River Hull (Yorkshire Region) in order to supplement the somewhat meagre information available on the value in use of water, the willingness to pay for reliability and the land value premiums created by a fish farm abstraction licence.

1.2.2 Value in Use Methodology

In an ideal world, value in use (as conventionally defined by economists) can be established by constructing the demand curves for different types of abstractor or 'in-situ' water user for different water products (ie of variable quality, reliability and seasonal availability). However, where no unit prices exist or where existing low price levels only allow, at best, the construction of a fragment of the demand schedule, it is necessary to derive 'surrogate' value in use information. There are four basic methods of assessment which can be employed.

(1) Value of outputs (productivity gains) generated by water use and productivity losses from restricted use. Such data can be derived experimentally by measuring the dose-response relationship between the amount of water applied and the resulting levels of output. This approach can be useful in the cases of irrigation and fish farm supplies, but has limited applicability for other abstraction demand

sectors. Alternatively, measures of the productivity gains from water use can be obtained under actual as opposed to experimental conditions by analysing the share of a business's revenue attributed to water inputs. Once again this method is most appropriate for irrigation and fish farming.

(2) Expenditure on alternatives to direct water abstraction at the needed time of use. Conceptually, at least, piped water supplies are a substitute for abstracted water for industrial and agricultural users; some idea of the maximum value in use of abstracted supplies can, therefore, be established from the costs of mains water, minus any differential expenditures incurred in treating the two sources of supply. The value of reliability can also be estimated where abstractors have supplemented their supplies during periods of shortage from the mains system. Another type of alternative expenditure arises when capital is substituted for water through, for example, the development of storage facilities; investment in recycling, or the installation of more water efficient technologies. A further version of this approach has been widely employed to derive values for recreational or amenity uses of water. The assumption is made that the costs of travelling to a water-based recreational site represents the willingness of users to pay for the experience and thus allow a crude value to be deduced for the site itself.

(3) Hedonic prices The value of water, a water amenity site or an abstraction licence is inferred from any observed differences in property or land values.

(4) Contingent Valuations. Rather than attempting to deduce values from the observed (revealed) behaviour of water users, methods of contingent valuation ask users to state their preferences for, or respond to, hypothetical situations. Various techniques can be employed, ranging from relatively simple questionnaires, which ask, for example, how much users would be prepared to

pay for an improved water supply, or whether consumers would take advantage of a tradeable permit scheme, to quite sophisticated bargaining games.

None of the surrogate demand estimation techniques is problem free and there is a strong probability that the derived value in use will differ greatly depending on the specific technique adopted. Care has, therefore, to be taken in interpreting the results.

1.2.3 Measuring Allocative Performance

In assessing the performance of the current and any future potential system of allocating and pricing abstraction supplies, it has to be acknowledged that there are several management objectives which the allocative system might be required to serve.

Although economic efficiency has been employed in this report as an important objective of water resource management, other potential goals have been employed when assessing the feasibility of employing incentive pricing or alternative economic tools and when attempting to define 'reasonable' water needs or the 'proper use' of water. Four such goals were assumed to be of greatest importance: first, the minimisation of the administrative burden associated with any allocative system; second, the need to generate sufficient revenue to cover NRA operations; third, the desire to ensure that statutory responsibilities for the protection of the water environment are met; and, finally, the need to ensure that the resultant resource allocation conforms to acceptable notions about distributive equity.

1.3 Report Structure

The final project report has been submitted in two volumes. A summary volume gives the main conclusions and recommendations, while this technical volume includes information derived from both the empirical research and the literature surveys, and also provides the details of the arguments underpinning our conclusions. Apart from this introduction, the technical report contains 7 chapters.

Chapter 2 reviews the theoretical approach to water pricing, setting out the rules and principles underlying efficient price structures and the ways in which these principles might be applied to meet the specific circumstances faced in allocating abstraction (and in-situ) water. The practical problems likely to be encountered in implementing incentive, cost based pricing are highlighted and overseas experience will be discussed. Tradeable abstraction permits are an alternative economic tool to unit pricing which theoretically can ensure a more efficient allocation of water resources. The theoretical case for their introduction is considered and the potential problems involved in their implementation are identified.

Chapters 3, 4 and 5 address the issues of the value in use of water and the willingness of abstractors to pay for additional supplies or improved reliability. The chapters investigate in turn irrigation use, the industrial and urban demand sectors and 'in-situ' uses. Each chapter reviews the evidence on value in use contained in literature both for Britain and overseas. They also present the results of the field investigations conducted as part of this project.

In Chapter 6, attention is focussed on NRA cost structures and the development of a cost attribution methodology. The preliminary work on cost related pricing already conducted by the NRA is discussed and an indication is given of the ways in which prices established from this exercise diverge from those required for allocative efficiency. Using data derived from the NRA's Yorkshire region, a hierarchical cost allocation methodology is discussed, which breaks down the total work of the NRA into a series of activities designed to provide particular services to particular end users or uses. The inevitable problems involved in the allocation of common costs are also discussed and alternative methods of dividing these costs between services and users are assessed.

Chapter 7 begins the examination of the feasibility of using cost-based incentive pricing and tradeable permits as demand management tools. It uses evidence from the literature and from the field surveys to assess the likely response of abstractors to any pricing or trading system. Water company reaction is also discussed, with particular attention paid to the way their charging policies and leakage detection practices may alter in response to a revised abstraction charge scheme. 'Feasibility' is also a central theme in Chapter 8, which seeks to bring together our conclusions and set out the practical role of economic tools as aids to NRA decision-making. The chapter will begin with a review of the new national abstraction charging scheme. Suggestions are made of ways this scheme could be adapted to produce a more economically efficient resource allocation under current legislative constraints and under less restrictive conditions.

2. MARKET MECHANISMS - THEORY AND PRACTICE

2.1. Introduction

The purpose of this chapter is to review the theory and practice of market mechanisms in the allocation of water resources between competing users and in the determination of the need for investment in additional resource supplies. It will first outline the conventional theoretical approach to water pricing and set out the basic rules and principles underlying efficient pricing structures. Next the practical problems involved in establishing such pricing structures will be discussed and the likely implementation problems identified. There are undoubtedly circumstances where the informational requirements of per unit pricing, the uncertainties involved in predicting consumer response and the potential socio-economic and political impacts of 'optimal' pricing will limit its acceptability in practice. In such conditions, it is possible that an alternative economic tool - the tradeable abstraction permit or marketable right - has an important role to play in improving the efficiency with which water is allocated between users. The third part of the chapter will consider the theoretical case for such trading systems and identify the potential problems involved in their implementation in practice. Throughout, the discussion of prices and trading will be informed by our survey of overseas experience with such mechanisms. Finally, in the last section of the chapter, the potentially optimal market based allocation systems will be briefly discussed.

2.2. Theoretically Optimal Unit Pricing

2.2.1. Marginal Cost Pricing

In order to ensure that any resource is distributed between consumers in an efficient manner two pricing conditions must be fulfilled. First, each class of consumer must pay the marginal costs incurred in supplying them, and second,

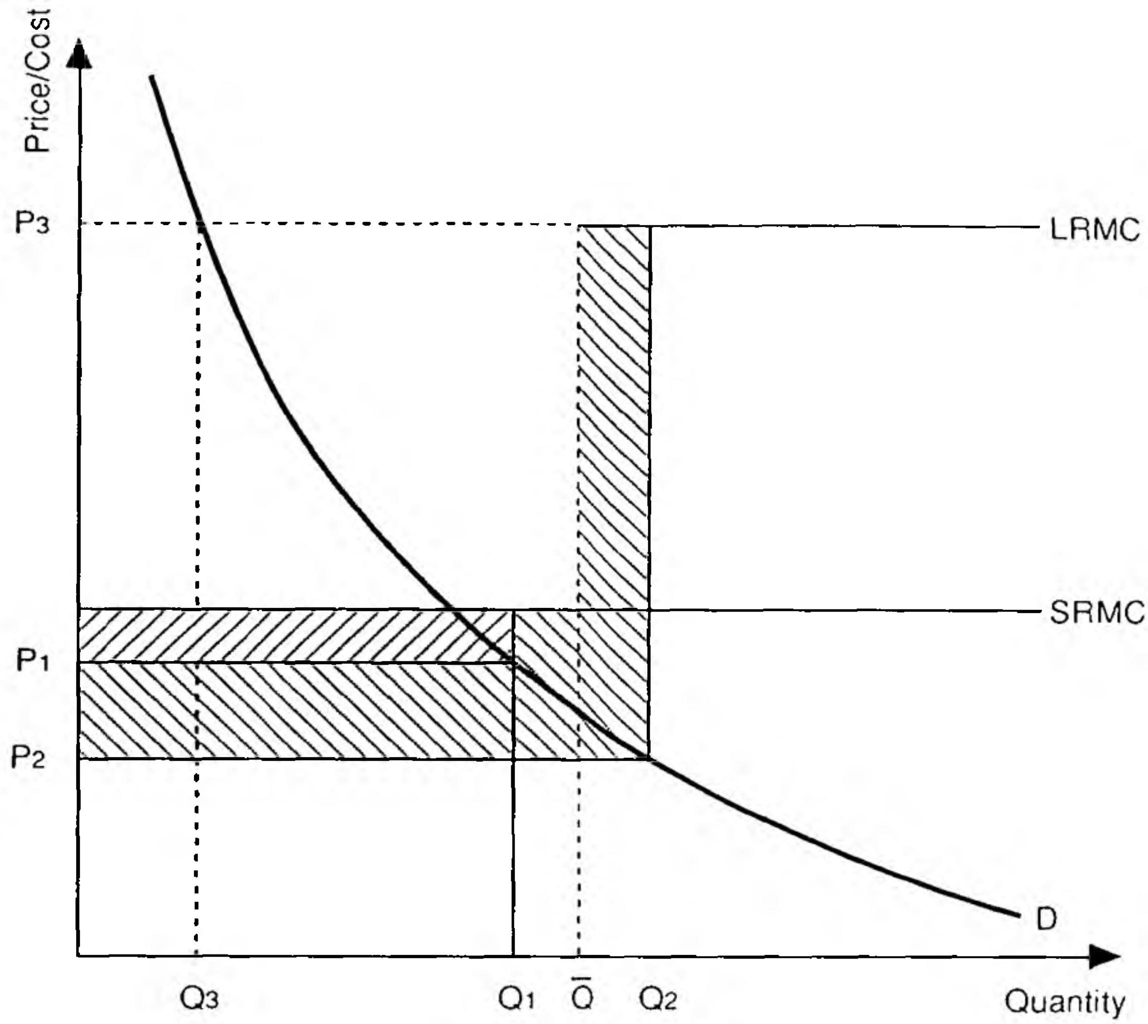
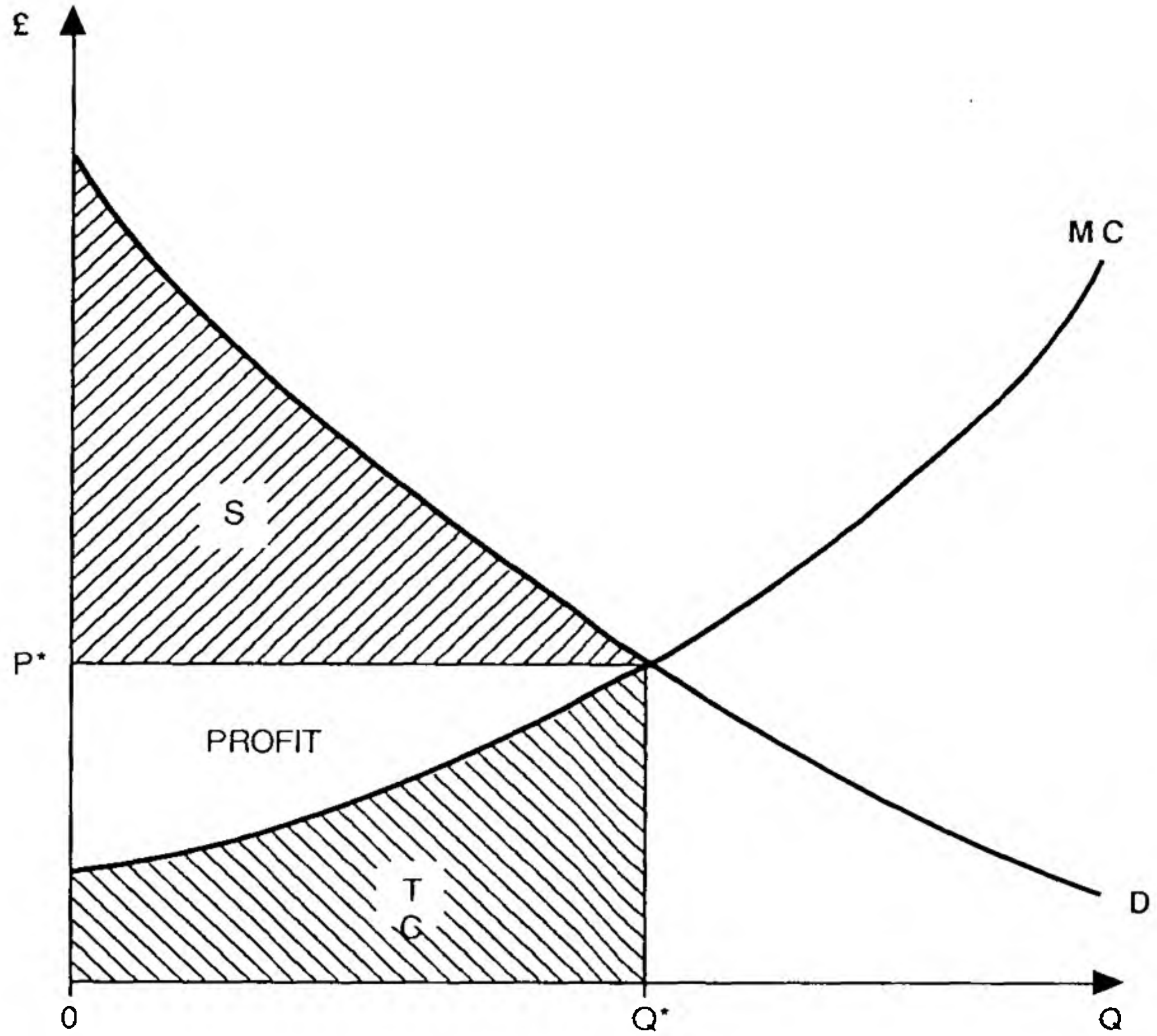


Figure 2.1 If the price of water is set at P, consumers will demand Q1. As long as capacity is sufficient to meet demand at this price level the subsidy on consumption will be confined to the difference between the price level and the short run supply costs: the area shaded . However if the price were low enough at, say, P2, then demand would exceed current capacity $\bar{Q}$ and new capacity would be needed. The subsidy then expands rapidly; even if capacity could be increased to exactly Q2 the subsidy is now the shaded area . (If there are indivisibilities the required subsidy escalates even faster.) Only if prices were set at P3 would consumers be paying the full costs their demands are now imposing on the system, but given the demand curve above demand at price P3 would fall (to Q3) and the extra investment becomes unnecessary.

within each supply cost category, the unit price must be set equal for all consumers.

The economic logic behind the first condition is clear. If consumers are not faced by prices which fully reflect the full marginal costs of providing them with goods and services, then their demands will be inflated. These inflated demands can only be met if other users or taxpayers are prepared to subsidise the consumption. In the short-run, where total demands are within the available capacity of the water system, such subsidies will be low. However, if investment takes place to expand capacity in order to meet the inflated demands, then the subsidies become large and obvious. (Figure 2.1). On the other hand, if capacity expansion fails to take place it will be necessary for the supply authority to introduce physical rationing rules in order to keep supply and demand in balance. This is basically the situtation under which the NRA currently operates.

The second pricing rule is derived from the economists' approach to allocative efficiency, or the maximisation of the net benefits yielded by the use of resources or factors of production. When the assumption is made that the willingness of customers to pay for a good is a measure of the value of that good to them, then the total value (utility) derived from a fixed quantity of that good is maximised when all customers pay the same unit price. This is illustrated in Figure 2.2 for the simplest case when only two customers are competing for the good. Pricing thus becomes a mechanism for ensuring that a product is transferred from low to higher value uses until the total value is maximised.



Figuer 2.2 Marginal Utility Curves and the "optimal" Pricing Rule.

Clearly the equal price rule only operates when customers fall into the same marginal supply cost category. Charge variations are desirable if the service costs vary by location, supply source or customer type; equal charges would result in inefficient cross-subsidy flows between customers. As far as the NRA is concerned the need to establish supply cost categories does not raise particular difficulties if marginal costs are measured solely in terms of the capital and revenue expenditure incurred to make abstraction water available. Within integrated catchments the marginal costs will be broadly equal for all abstractors, although this will not apply when discrete surface water supply areas or ground water sources are involved. However, as will be shown in 2.2.4, if marginal costs are calculated, as they ideally should be in opportunity cost terms, then the possibility arises that the marginal costs imposed by each abstraction will be virtually unique.

It has to be stressed that under theoretically optimal conditions all water users should be faced by the same marginal unit price irrespective of whether the water was abstracted or employed 'in-situ'. From a pure efficiency perspective it would not matter whether the resulting allocation of supplies resulted in extreme low flow conditions, so depriving the river of its recreational, environmental and amenity functions. If the NRA, or any environmental group, was willing to pay to retain these functions then they should enter the market and buy the necessary supply units. Only when all users were deriving equal marginal value from the resource (as measured by their willingness to pay) would the total utility derived from the resource be maximised. Such a pure pricing scenario is, of course, unlikely to be politically acceptable; in practice environmental and amenity interests are unlikely to play a significant role in the market. Moreover, some would argue that ethically it would be inappropriate for them to do so; rivers and the dependent ecological resources have intrinsic values and survival rights which human beings have a duty to protect. In such a case pricing within a limited capacity (2.2.5 and 2.3.4) becomes the potentially appropriate charging system.

2.2.2. Different Water Products : Seasonality and Reliability

Abstraction water is not just one product but several with vastly different quality and reliability characteristics. Efficiency would require that the different marginal costs involved in supplying these various products are reflected in the prices faced by consumers. Only in this way will the product range and the quantities of each product supplied reflect consumer preferences.

In the water case the most significant product differential arises over the time period during which water is abstracted. Many industries have to face regular or irregular fluctuations in the demand for their products and well-developed theories of peak-load pricing exist to cope with the problem. Capacity requirements are determined by the peak demand and prices need to reflect this fact. In its simplest form, peak pricing theory leads to the recommendation that during off-peak periods (i.e. winter) when demand is axiomatically within capacity limits, short-run marginal costs should be levied. In the NRA's case these will be minimal. However, demands served during peak summer periods should attract all the costs involved in providing the supply capacity.

Matters become more complicated when supply irregularities compound 'normal' demand fluctuations, and particularly so when the variations in peak demand and supply availabilities are inversely correlated and are both subject to uncertainty. Clearly this is precisely the problem with the NRA. Ideally, the storage capacity provided to meet the coincidence of low flow/peak demand conditions should reflect the willingness of abstractors to pay for reliability. Since it is quite conceivable that abstractors along one river will have quite different reliability preferences, it would be theoretically possible to have differential prices and to 'cut' abstractors off from supplies once conditions worsen past the particular reliability threshold they have paid for. The practical problems involved in policing such a system would, of course, be considerable.

It is never likely to be optimal to provide sufficient capacity to overcome the worst conceivable low-flow-peak demand conditions. In this case peak price surcharges can be employed as demand 'choking' or rationing devices : prices are simply raised until they are high enough to get demand and available supplies into balance. The conceptual simplicity of such price rationing schemes belies the very real problems involved in calculating what available supplies actually are in situations when it is impossible to predict when droughts will break.

More complex pricing rules can be developed to take account both of the quality of water held in storage, either natural (as for ground water) or manmade, and of the Authority's knowledge of drought probabilities (Rees *et al* 1987). Such rules are most immediately relevant to the NRA when stochastic variations in supply occur during the winter months and result in failure to recharge storage capacity. Under such conditions abstraction even during the normally low demand period will reduce the availability of supply at the peak. In this case winter abstractors should be faced by long-run marginal capacity costs since they are in effect using up the capacity actually developed to meet the demands of summer users.

2.2.3. Supply Quality

A second potentially important product difference arises over supply quality. For most conventional suppliers of goods and services the fact that customers have preferences for different quality products raises no particular charging problems: prices are set to take account of the different costs involved in producing higher or lower quality goods. For water, matters are not this simple. In the case of network supplies, where one quality has to be provided for all customers along a particular network some notion of average preference could be employed but for rivers, where quality is determined by flow characteristics, weather conditions, bed conditions and the behaviour of other river users, the situation is highly complex. Where the quality supplied to an abstractor is determined by nature or by NRA policy to protect recreation or environmental interests then the costs of achieving that quality is not part of the legitimate costs of abstraction supply. Although it is true that the value of the abstracted water to the user will vary with the quality, it is the cost of supply which is relevant to charging policy.

However, there will be cases where the fact that particular types of abstractor are present on a river will lead to demands for increased pollution control. This most obviously applies when surface waters are used as sources of drinking water supply. In such circumstances it would be possible to argue that differential charges based on product quality should be levied.

2.2.4. Marginal Opportunity Costs

The conventional economic approach to marginal cost pricing has typically been concerned with the revenue and capital expenditure made to provide the supplies of a particular good. For abstraction water such expenditures are only a part of the true costs imposed by an abstractor on the system. In any situation where there is not sufficient capacity to serve all the demands of abstractors and 'in-situ' water users, abstraction could impose losses on others. For example, if set river quality objectives have to be met, abstraction could result in more stringent direct discharge standards being imposed on polluters. Likewise abstractions could reduce the value of the rivers as recreational resources or as supporters of wildlife. The losses thus imposed are the opportunity costs of the abstraction and are additional to the capacity enhancement costs. Importantly, such opportunity losses can vary enormously throughout a river system and over time. Losses, for example, could be higher if the abstraction took place relatively high up the catchment or during times of the day which coincided with the natural oxygen sag. Likewise, the losses incurred by any one particular abstraction would vary with the behaviour of other abstractors and water dischargers. Although in theoretical terms charges should include opportunity costs, in practice the informational requirements and the costs of implementing such a system are likely to make this an untenable option.

2.2.5. Incentive Pricing - Rationing by Price

In the above sections pricing rules have been considered which attempt to relate charges to the costs imposed by abstractors (and notionally 'in-situ' water users) on the resource system. There are, however, situations where the NRA might employ charges purely as a rationing device to replace (or supplement) 'command and control' forms of use regulation. These situations occur when there are natural or bureaucratically determined constraints on the total quantity of supply within a water system available for allocation to abstractors. In other words the abstractors are operating within set physical supply limits. Such limits may be temporary in exceptional drought conditions; medium term when capacity development has lagged behind willingness to pay for the supply enhancement; or even permanent if supply increases are naturally or politically impossible. Under a physical limits scenario it is no longer necessary to base charges on costs, but to increase prices until supply/demand balance is achieved. Theoretically only those employing water for the highest value purposes would continue to abstract supplies. In practice, the Authority would need quite detailed information about abstractor demand curves in order to establish the appropriate 'rationing' price. Moreover, such prices would need to be carefully adjusted to maintain the required supply/demand balance in response to demand curve shifts and changing real prices in the economy.

2.2.6. From Theory to Tariff Practice

Theoretical considerations have produced three rather different approaches to charge setting :

- prices fixed by the marginal capacity and revenue expenditure on supply enhancement .

- prices related to the opportunity costs (or damage losses) imposed on other water users.

- prices as purely rationing devices.

We turn now to considering how these different pricing principles might be incorporated into an abstraction charge tariff structure.

2.3. Charge Types and Tariff Structures

2.3.1. Types of Charge

Basically there are three different types of charge which should be levied within an efficient charging scheme. Ideally they should be employed together to capture different elements in the cost of supply provision.

(i) Access fees - these are one-off and/or annual fixed payments for a licence to abstract water. They should be employed to recover the non-consumption related costs imposed on the regulatory agency. These include the initial administrative costs of issuing the licence, meter installation and reading, monitoring to see that licence conditions are met and the costs of collecting the abstraction charges. Such costs may vary between consumer groups', for example, very large users would require a large meter and may need more frequent meter reading, but in all cases this will be a minor element within an efficient tariff scheme structure.

(ii) Availability Charges - these are the capital and opportunity costs imposed on the resource system by 'reserving' a supply for the licence holder. They should be levied on the quantity of water authorised under the abstraction licence and should be set to reflect the long-run marginal supply costs.

(iii) Actual Unit Abstraction Charges - these should be set to recover the operating costs of the resource supply system (any pumping costs for example) and the damage costs imposed on other users when capacity is limited. Under 'normal' climatic conditions and assuming that the NRA (or water companies) undertake investment in new capacity, actual use charges will be relatively small, since the key capacity costs will be recouped through availability charges. However, significant use charges are justified when drought conditions or capacity limits exist.

2.3.2. Availability Charges

Availability charges should vary spatially in line with the long-term marginal costs involved in serving different locations within an NRA region. For example, abstractions from estuaries rarely need supporting by supply augmentation and do not materially affect other water users : the availability charge would, therefore, be zero. In integrated catchments, all users would benefit from enhancement in one part of the system and, therefore, should face the same authorisation charge. However, where catchments or ground water sources are isolated, the long-run marginal cost price should be specific to those sources. It has been stressed that there is no economic justification for charging different types of abstractor different per unit authorisation prices, except under seasonality and return flow adjustments.

As seen in 2.2.2, demand season and variable supply reliabilities require adaptions to the simple rule that charges for authorised abstractions should be set at the long-run marginal cost. In the case of most surface water sources, the unit capital cost incurred to serve winter abstraction is zero and no availability charges should be levied. This means that all the long-term costs of supply enhancement should be allocated to summer abstractors, irrespective of what they take during the winter. The present policy of allowing all year round abstractors to pay less for their summer consumption than summer only users results in false cost information being transmitted to users. Such lower rates are usually justified on the grounds that constant year round abstractors do not impose peak supply costs on the authority. This is false logic: all peak users impose the same marginal costs irrespective of their annual use cycle.

As discussed in 2.2.2, if the NRA was willing and able to stage any capacity enhancement programmes to meet variable demands for reliability, then there would be different long-run marginal costs for different levels of reliability. Those users producing high value products and demanding supply security would opt for the more reliable and high cost product.

In the case of ground water abstractions it is more difficult to use economic theory to provide unequivocal charging rules. From one perspective, it is irrelevant when the abstracted supply is actually taken; it is the total amount abstracted over the year which affects future resource availabilities. This suggests that the ground water availability charges should not vary with the seasons. However, ground water can also be regarded as a special case of a constrained supply situation in which the demand choking actual use charges discussed in 2.3.4. could be more appropriate.

2.3.3. Return Flows

Efficient availability charges also have to be adapted to account for differences between abstractors in the quantity of water returned to the supply system after use. As far as winter abstractions are concerned the proportion of supply accounted for by return flows will normally be irrelevant as return simply adds to the potential supplies 'lost' to the sea; no refund discount is, therefore, appropriate. There are, however, cases when winter returns contribute to the replenishment of down stream reservoirs or even to aquifer recharge; in this eventuality a reduced per unit charge for high returns would be appropriate. For summer abstractions return flows are clearly relevant as they act to reduce the total capacity needed to serve the system.

If we simplify the situation by ignoring the quality of the discharge and assuming that all the returned flow is available for reuse, then the pricing rule is easily established. Only the consumed water units should attract the availability charge. Since all the long-run marginal costs of supply augmentation are placed on the consumed units, the marginal unit charges for consumptive use would be very high. Consumed units would include those incorporated into products, evaporated or returned to estuaries, the sea and any other points in the catchment(s) where reuse, even for 'in-situ' purposes, is not required.

The calculation of consumed units should also take account of the point of return where this has a significant impact. For example, if a fish farm abstracts a large proportion of the flow in a river and returns it unchanged but to a point downstream, this can have severe consequences for the stretch of river between the points of take-off and return. The charge should reflect this, and would provide an incentive for the fish farm to pump the water back to a point close to where it was abstracted.

In reality the quality of the returned water cannot be ignored, as polluted returns will obviously impose opportunity costs on 'in-situ' river users and may also limit reuse potential. Ideally, these opportunity costs should be captured in direct discharge charges and it would clearly be double counting to impose the same costs on abstractors through the abstraction charge itself. However, in the current situation where pollution charges are unrelated to the damage caused by a discharge, it could be argued that it would be a second-best solution to take account of the reduced value of polluted return flows in the abstraction charges. Notionally any return flows of diminished quality should attract a charge equal to the difference in value of the water to other river users at its pre- and post-abstraction qualities. The information and implementation costs of such a system would, however, be extremely high.

2.3.4. Actual Use Charges and Constrained Capacity

It has been conventional to assume that the charges for actual (as opposed to authorised) usage will be low, confined to system operating costs. However, this assumption is not necessarily valid. There are two situations where high and potentially very high charges could legitimately be charged against actual consumptive use. First, in exceptionally low rainfall periods where drought conditions exceed those incorporated in the design of the supply capacity, then high actual use charges could serve to ration available supplies and prevent potentially irreversible damage to river ecosystems. Such charges could replace the current bans imposed on particular classes of abstractors and would ensure that available supplies were allocated to the highest value uses. Second, demand-choking actual use charges could be employed on a more regular basis where natural or political circumstances make capacity enhancement impossible. Some aquifers, for example those near the coasts, cannot be recharged effectively. In these conditions, supplies are fixed; there are no meaningful long-run marginal costs of supply enhancement and thus availablility charges are not legitimate. Actual consumption charges employed as a rationing device are, therefore, more appropriate.

The effectiveness of actual use charges in rationing limited supplie, clearly depends on the short-run elasticity of demand. In all probability some physical constraints on use would also be necessary to prevent gross over-abstraction. Charges based solely on actual use also have the disadvantage of providing no incentive for licence holders to relinquish any un-used component of their abstraction right. This problem can be addressed by levying a two part tariff with one element based on authorised and the other on actual usage (ie as per the current arrangements for irrigators but with the actual charge set high enough to curb demand. Alternatively, and possibly more satisfactorily, the re-allocation of abstraction rights in supply limited catchments or aquifers could be encouraged by allowing permit trading to occur, but with the NRA having the ability to levy actual use charges to cope with situations when low flow or poor winter re-charge took available supplies below the authorised quantity.

Such natural barriers to supply capacity expansion are rare for a renewable and reusable resource such as water. From an economic perspective it is not efficient to limit demands, even at peak periods, because it is assumed that conservation per se is the objective of water management. In other words demand control in itself is not a legitimate policy end, but is a tool to ensure that supply enhancement only occurs when the value of the new water exceeds the costs of supply. However, it is recognised that there are politically determined conditions under which the NRA cannot embark on investments in capacity extension. Where this is the case, actual use charges could be employed to ration available supplies, instead of other bureaucratic rationing rules.

2.3.5. Block Tariffs

Although block tariffs (declining, increasing or 'excess' use) are commonly encountered in implemented charging schemes, they can rarely be justified on economic grounds. Clearly all forms of block schemes contravene the basic rule that all users should face the same marginal cost price. Declining blocks, where large consumers are given a lower marginal unit price, clearly reduce incentives for economy in use and discriminate against small users. Increasing blocks are normally justified either on equity or on conservation grounds. Very high marginal unit prices could exclude relatively low income users from the market (small farmers for example) increasing blocks can act to protect their usage. Likewise, in overabstracted catchments, where the supply is fixed (at least in the short term) increasing blocks applied to both availability and actual use charges could effect a more speedy reduction in usage to achieve the required supply/demand balance. Excess use blocks are sometimes employed as a device to curb summer usage; they work by allowing consumers to take peak season water up to their normal winter usage at one price level but any 'excess' usage is subject to a surcharge. Such a system is not economically efficient since all summer use, 'normal' or 'excess', imposes the same supply costs on the system.

2.4. Information Constraints

Efficient per unit pricing systems often involve the need for much better cost and demand information then the NRA has, or is ever likely to have, in practice. Superficially, charges based on marginal capital and revenue costs should be relatively simple to calculate, and indeed as total figures they are. However, the allocation of such costs to particular abstractors raises very real difficulties, because of the prevalence of common costs (see chapter 6). Information problems are much greater if charges are to be fixed on an opportunity cost basis. Not only are some of the damage losses intrinsically difficult to quantify, but also they vary enormously over space and time, with weather and river flow conditions, and depending on the behaviour of other abstractors and 'in-situ' users. To implement such damage based charges 'optimally' the NRA would be involved in developing charge systems which were virtually unique to each abstractor and would be incurring ludicrously high information collection, monitoring and implementation costs. Likewise, incentive/rationing charging schemes require good (and constantly) updated information about abstractor demand curves if the desired supply/demand balance is to be maintained. Without good data about abstractor costs and likely response behaviour, there is little certainty about the impact of the charges. However, such information can only be obtained at a very high price, with quite detailed modelling required of abstractor industries. Such information problems have frequently led to the suggestion that tradeable permits are preferrable to unit pricing as tools of economic regulation (see Tietenberg, 1990).

2.5. Management Objectives

2.5.1. Non-Efficiency Objectives

Advocacy of unit pricing systems is based on the notion that economic efficiency (as conventionally defined) is the objective of public policy. In reality there are at least nine sets of objectives which a resource management agency, such as the NRA, might seek to fulfill or be required by Government to fulfill:-

Economic Efficiency

- allocating appropriate water services over time and between customers to maximize the total net benefit to the community as a whole.

Financial

- raising sufficient revenue to cover costs (this may also involve the need to avoid making profits)
- ensuring revenue stability to ease budget balancing
- minimising administrative costs to meet budgets.

Environmental Protection and Conservation

- minimising environmental change
- protecting environmental/conservation values
- ensuring an appropriate allocation of environmental quality resource over space and time.

Distributive Equity

- ensuring that the water resources and costs are allocated according to accepted notions of equity and justice.

Community Wellbeing, Employment and Development

- promoting or protecting development and employment in particular regions or economic sectors
- ensuring water resource development keeps pace with needs of the economy.

Public Health and Hygiene

- protecting water sources from health-threatening forms of pollution
- ensuring that public supply authorities have adequate water to provide essential health and hygiene requirements.

Minimising Political Intervention

Minimising Public and Press Dissatisfaction

Increasing the Power, Profile and Influence of the Agency

The patterns of water development, allocation and cost recovery which best meet any one of these objectives may, and probably will, be incompatible with the achievement of at least some of the other goals. It is well know, for instance, that a Pareto efficient allocation could be achieved if 90% of the available water resources were allocated to only 5% of potential abstractors. Clearly, any pricing system is based on the notion that willingness to pay is a true measure of the value of a good to individuals; in reality ability to pay is crucial. Water resource policy is inevitably a trade-off process between desirable management objectives.

2.5.2. Efficient Tariffs and NRA Financial Performance

The most obvious financial problem which could arise from the implementation of tariffs which approximated to those required for efficiency is that the NRA would probably make considerable profits. This arises since the marginal cost of augmenting or re-distributing resources is thought to far exceed average costs (see Figure 2.3). The problems involved are compounded by the generally 'lumpy' nature of augmentation expenditures. There would clearly be a need for the NRA to store profits to fund the next supply enhancement programme. Possible difficulties with the Treasury are foreseen since they may wish to retain control of public expenditure and refuse to allow revenue to be earmarked for specific expenditure purposes at some future, but to some extent uncertain, point in time.

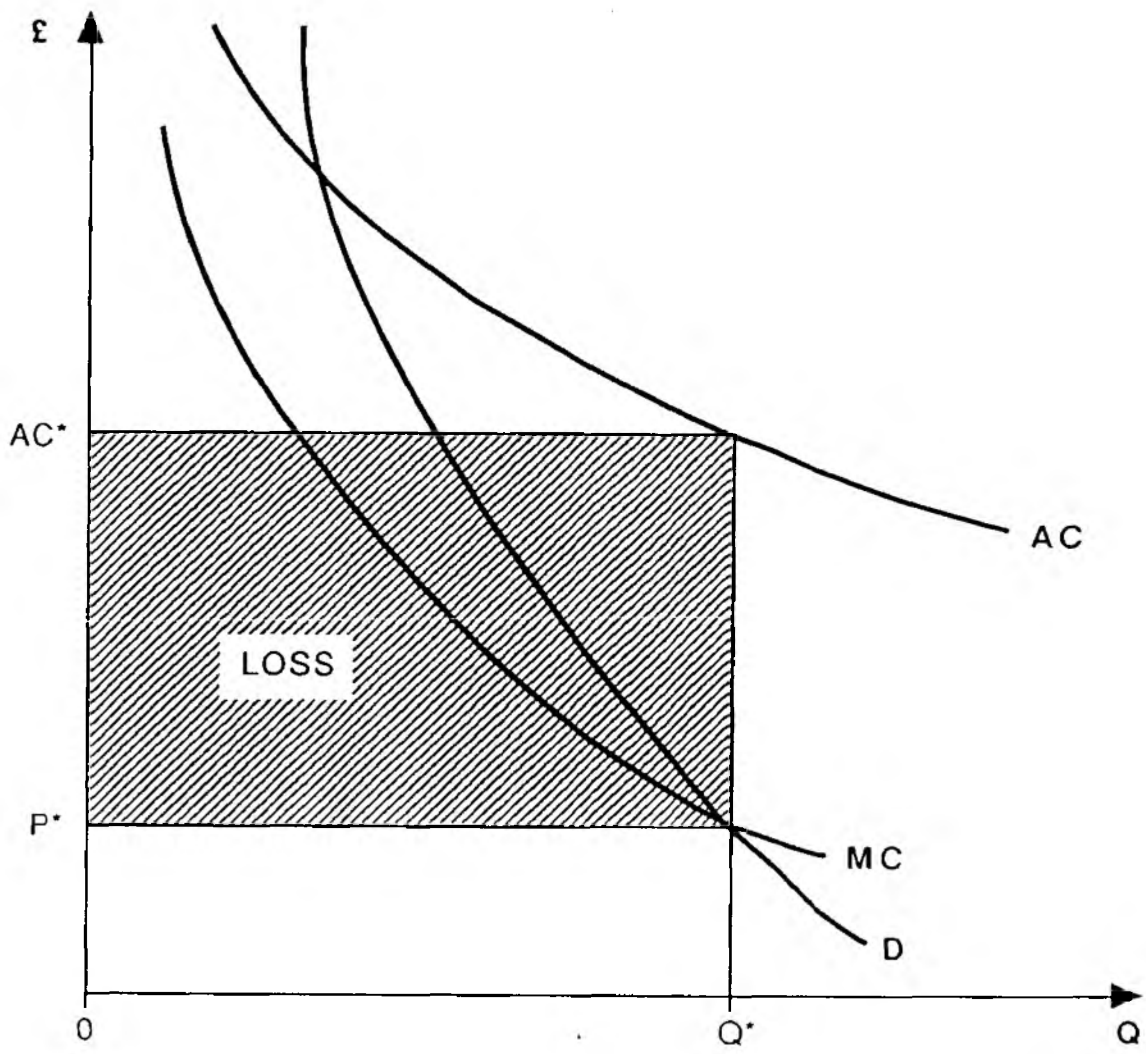


Figure 2.3 Marginal-Cost Pricing with Decreasing Costs.

It is, however, possible to regard such excess profits not as a problem but as an opportunity. Profits made on abstraction could be employed to support water using activities which, by their nature, are not profit making; supplying the environmental functions of the rivers for example. Such a system would still allow abstracted supplies to be efficiently allocated, although, of course, the total allocation of water resources to all river users would be determined not by efficiency but by equity or environmental criteria.

2.5.3. Environmental Protection and Wildlife Conservation

Economists have traditionally regarded the environment as having only instrument value as a provider of goods and services desired by human beings. Environmentalists (and the new breed of environmental economists), however, argue that intrinsic values can be attached to environments and non-human species. If the NRA takes an instrument value approach and sees its objective as achieving an appropriate balance between extraction and 'in-situ' river functions, then conceptually there need be no incompatibility between efficiency and environmental objectives. In reality, however, the problems involved in actually valuing and attaching prices to environmental uses (see Chapter 5) limits the use of charging as the mechanism to achieve such a balance. Moreover, even if we ignore such valuation difficulties and assume that a perfectly operating pricing system will maximize the net social instrument value of available resources, there is still no guarantee that the result would protect all those environments or species regarded as having great intrinsic value by at least some groups. In all probability judgements about desirable environmental quality and wildlife conservation will be made politically. Charging schemes can be employed to help achieve these quality goals but not to establish the goads per se.

2.5.4. The External Costs of Efficient Pricing

If willingness to pay is not a true reflection of value in use then conventional pricing rules would still fail to maximize the net total utility derived from available water resources. The fact that ability to pay limits can create a divergence between willingness to pay and utility (or value) is well known. In addition, an efficient allocation of water could result in inefficiencies in the allocation of 'dependent' resources, such as land, labour and fixed community assets. For example, high marginal cost prices for a peak consumptive water use, such as irrigation, could easily result in farmers moving out of irrigation and, indeed, out of agriculture entirely. This could well increase the value in use of water, but add considerably to the social costs of rural decline. In theory, if the market system was working perfectly in the economy as a whole, the newly unemployed labour, land and capital would move to other sectors where their value in use was higher. However, in practice with immobile factors of production (such as land, community infrastructure and labour with few non-agricultural skills) the external costs of efficiency in water use would be considerable and long-lived.

A rather different form of external (or spillover) cost of an efficient water pricing system must also be noted. That is the tendency for farmers using the most intensive agricultural techniques to be willing and able to pay the highest water charges. Intensive farming, dependent on inputs of pesticides, fertilisers and mechanisation, not only creates pollution problems and potential reductions in the amenity value of land, but also need not be sustainable over time (see Chapter 3).

2.6. Pricing and Overseas Practice

2.6.1. Introduction

Given the informational and implementation problems encountered in employing efficient abstraction pricing systems, it is perhaps not surprising that no known charging scheme exists which even approximates to the theoretical optima. In all countries it is recognised that efficiency cannot be pursued to the exclusion of other objectives. Where charging systems are in operation, an abstraction licence or consent, is still the primary, indeed often the only, allocative tool employed. The charges are employed to generate revenue and to distribute cost burdens in a politically acceptable manner, rather than as tools for the promotion of allocative efficiency. Most commonly, the only charges made are flat-rate access fees, unrelated to the quantity of water authorised or actually taken. Volume related abstraction charges appear to operate in only eight advanced countries - England and Wales, France, Netherlands, United States, Canada, Japan, Australia and Germany (but only in one Land) - although legislation has paved the way for their introduction in Spain, Italy and Portugal. A wider range of countries do, however, impose user charges for irrigators, where capital works have been constructed to serve particular irrigation districts. However, such schemes are normally highly subsidised and charges are set to raise the necessary revenue rather than to act as incentives to efficient water use.

2.6.2. **France**

From our review of overseas practice, we have concluded that the NRA has relatively little to learn about charging efficiency from other countries with abstraction charges. Only France is known to have a comprehensive unit charging scheme. Charges are based on actual abstractions, they are set to recover costs and are relatively low given government subsidies. Abstractors inform the relevant Agences de Bassin of their likely requirements over the year; charges are levied on these estimates but a balancing account is presented at the year end if actual usage diverged from the estimates. At present only 'state' waters are subject to the charging system, which leaves many smaller streams or large areas of ground water effectively unregulated. Legislation is currently before the French Parliament to bring 'non-state' waters into the regulatory system.

The specific details of the charging schemes vary between the Agences, but all tend to set differential charges (or weighting factors) based on

- the location (zone) of abstraction, to take account both of differences in the quality of the available water and the varying external (opportunity) costs imposed by abstractions in the various parts of a catchment. According to a spokesman from Compagnie Generaledes Eaux, these locational charges can be highly specific and targetted to solve particular problems; for example very high charges have been levied on sources with high nitrate levels to restrict their use.

- Surface or Groundwater
- Season

- The proportion of water consumed by use; this weighting factor is usually only employed in locations where consumptive use imposes significant opportunity costs on 'in-situ' or downstream users. Consumed proportions are not measured for each abstractor, rather 'restitution coefficients' are applied based on the estimated consumptive element in the usage of different consumer classes. In Seine Normandy, for example, it is assumed that 93% of industrial use is returned, 80% of public supplies, 60% for run-off irrigation and 30% for spray irrigation.

Although the principles behind the French system of weighting and restriction factors are broadly based on opportunity cost notions, it is widely recognised that the particular weights and factors employed are subject to political bargaining. Within each Agence the charging system is in effect negotiated through the Comites de Bassin, which are composed of an equal number of representatives from the water users and the local and regional government authorities. Moreover, the practice of basing the charges solely on actual rather than authorised consumption not only diverges from the requirements of an efficient tariff, but can also create revenue variability problems for the Agences. This is particularly so since there appear to be no pricing penalties imposed on abstractors who over or under estimate their abstraction for the year. Consideration has apparently been given to the idea that abstractors who exceed their estimated usage (a particular problem in dry years) would be subject to excess charges, but no known attempt has been made to implement such a system.

The French charging scheme which comes closest to the economic ideal is administered not by the Agences de Bassin, but by one of the separate rural water supply companies, the Societe du Canal de Provence et d'Amenagement de la Region Provencale. According to Herrington (1987), charges are based on the marginal capital costs of supply capacity and support works; all capacity charges are levied only on actual demand during the peak summer period and off-peak usage is free of all capital charges. In addition, irrigators pay an authorised abstraction charge for their peak period entitlement, which is set at the replacement cost of the water distribution network. Operating costs are levied on actual consumption irrespective of time of year. The supply area is divided into zones and consumers within each zone pay the marginal costs incurred to serve their zone; there is no cross subsidisation between zones. However, while this scheme shows what can be done, total charges are still reduced by a 50% government subsidy to protect agriculture and the water supply system is effectively a dedicated network, free of the problems of meeting 'in-situ' water needs.

There is one feature of the Agences' pricing system that could be considered for introduction in Britain, that is the reported use of highly targetted location weighting factors to discourage use of particularly problematic sources. Given the NRA's great concern with over abstracted catchments, there could be merit in levying an actual use charge, in addition to authorisation payments, to discourage abstractors from demanding their full 'entitlements'.

2.7. Tradeable Permits - Theory and Practice

2.7.1. The Theoretical Advantages

In recent years the environmental economics literature has highlighted the potential advantages of employing tradeable permits rather than volume related charges to allocate environmental capacity between competing users. (See for example Royal Commission on Environmental Pollution 1992). There are no conceptual differences between the use of such permits for the achievement of environmental quality objectives and for the allocation of water resources. Permit trading has six fundamental advantages over pricing. First, when there are fixed supply limits, permits ensure that these limits are met, which pricing does not unless the Authority has extremely good information about abstractor demand functions. Second, but closely related, permits impose few informational requirements on the Authority. Third, permits 'buy' the political acceptance of established abstractors to a more efficient allocation of available resources by giving them a 'de facto' property right, which they can then trade if it is profitable to do so. Fourth, since permit trades are 'optional' and will only gradually transfer resources to higher value uses the social costs involved are likely to be significantly reduced. Fifth, in theory the availability of permits can be tailored carefully to meet environmental and wildlife conservation objectives. And sixth, permits impose low costs on industry and other abstractors. Permit systems are not, however, a general panacea', they are most appropriate when supply enhancement is not an option and they clearly have a major practical disadvantage in providing no revenue for the NRA.

2.7.2. The Application to Water Resources

Tradeable permit schemes are not in fact a new idea, they have long been employed, usually under the name marketable rights, to reallocate water resources in the western United States. The most common reasons for using marketable rights lie in the nature of established water entitlements and the political/legal difficulties involved in either revoking them or introducing full marginal opportunity cost pricing. Transferability provides the opportunity to improve the efficiency of water use where the historic development of rights has fossilised usage patterns. Trading should automatically move supplies from lower-valued to higher-valued uses and "a competitive market that sets a market-clearing price directly confronts the potential user with the real opportunity cost" (Howe 1990).

In theory, permit market price setting is simplicity itself. A buyer's willingness to purchase various quantities of water authorisations will depend on value in use, which in turn will be determined not only by the purpose it will fulfil but also by the characteristics of the water itself (reliability, quality). Buyers will in effect create separate water markets for supplies with different quality and availability characteristics. In the United States, for example, so-called senior water rights, which take precedence in any shortage situation, are valued more highly than junior rights. Where supplies are unpredictable and no preferential rights exist, trades may be established for percentage shares in available flows, rather than for set volumes. Such share trades operate best where the water use system involves relatively few closely related abstractors, with an organisation capable of monitoring behaviour to avoid cheating.

Sellers will wish to enter the market when prices exceed a *reservation value*. Theoretically this reservation price will be determined by the profit which the potential sellers can achieve by using the water themselves. In practice, however, sellers may continue to hold rights above their value in use as speculation against future price rises, or if the value of property (land) is increased by the existence of an established water right. Industrialists, for example, may be unwilling to sell even an unused right if they anticipate putting their premises on the market in the relatively near future. Likewise, farmers may be deterred from selling any permit on a permanent basis if their land value declines as a result (see Chapter 3). Further imperfections are introduced into the market if agricultural support policies artificially inflate the profit on irrigated crops.

Willingness to buy and to sell will also be affected by the way the legislation allowing trading is framed. Two of the most important elements concern rights to resell any post-use return flows and the ability to sell 'excess' elements of an established right rather than the whole entitlement. In the latter case farmers, for example, could still stay in irrigated agriculture if they were allowed to sell off any supply units which they could free up (the American terminology is 'water salvage') by improving their irrigation technology or by changing their cropping regimes. A third issue of importance is whether the trade is a permanent transfer of rights or is merely a temporary (annual) sale of the water with the long term right remaining with the seller (in US terminology the latter is called water leasing or renting). Such temporary sales have been employed widely in Australia and the United States; as one would expect the prices achieved are well below those for permanent transfer.

Another key factor is the continuing role of any public regulatory agency or water court. Where, as is commonly the case, any trade has to be ratified by an agency or court (which also has the power to impose conditions on the sale and restrictions on the transferred permit not present in the original) regulatory risk may deter both buyers and sellers. Once demand and supply curves have been established for permit trades, the transaction costs and the physical costs of transfer have to be considered. Physical transfer costs include items such as pumps or pipelines needed to effect the transfer plus any losses of water in transit. Transaction costs involve legal or regulatory agency fees, any required hydrological survey work and the search for information about potential sales. In addition, they theoretically should also include any external costs imposed on other water users by the transfer, but in practice rarely do so. By and large these two sets of costs should decline per unit of water sold as the size of the sale increases, although this may not be so if externalities are taken into account.

With all the relevant information gathered it is then possible to establish whether scope for trading exists. Ignoring externalities for the moment, Figure 2.5

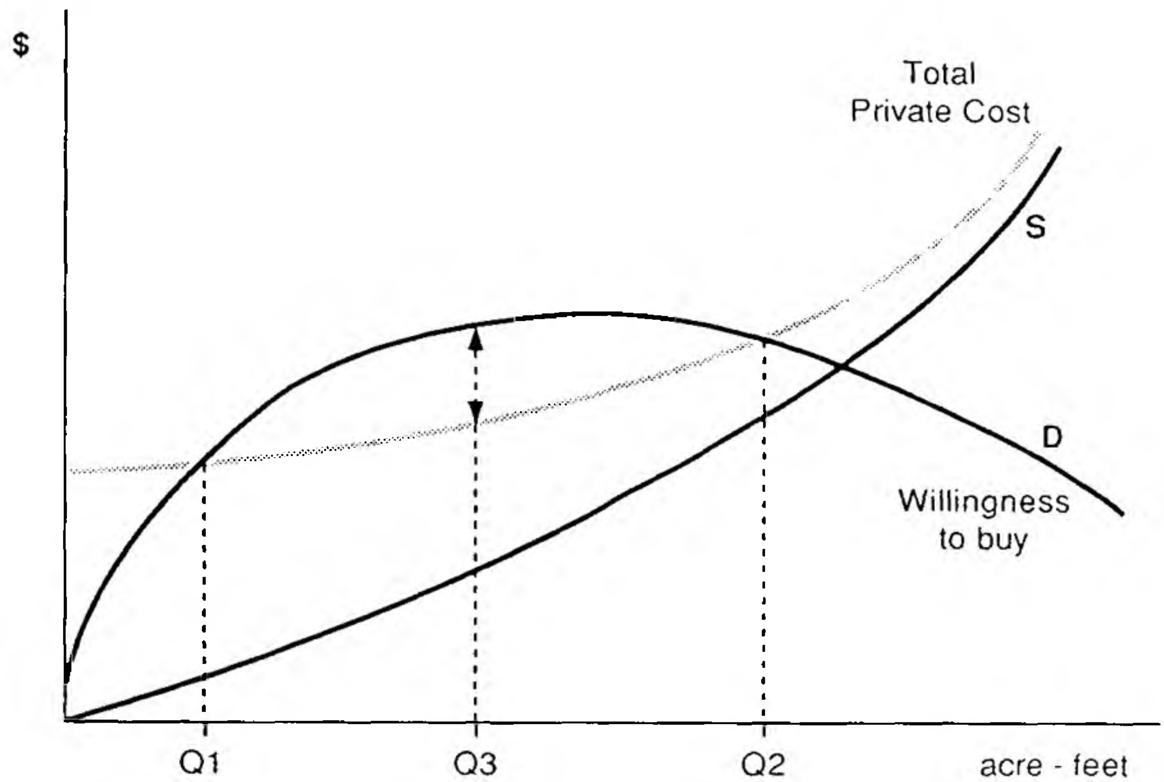


Figure 2.5 The Private Cost and Benefit Case.

illustrates a simple situation in which scope for permit transfer exists; between Q1, and Q2, the total cost to the purchaser (the sale price plus transfer and transaction costs) is less than the price that the buyer is willing to pay. Q3 represents the point at which the net private benefits of the transaction are maximized, but a bargained sale could be advantageous to both parties anywhere between Q1 and Q2. The regulatory agency (or court) can utilize this information, adding in any external costs to establish whether the sale could yield *social benefits*. As Figure 2.6 shows, when external costs are added to the total private costs, the potential room for sale has between restricted to Q1 - Q4, but a socially beneficial transaction is still possible.

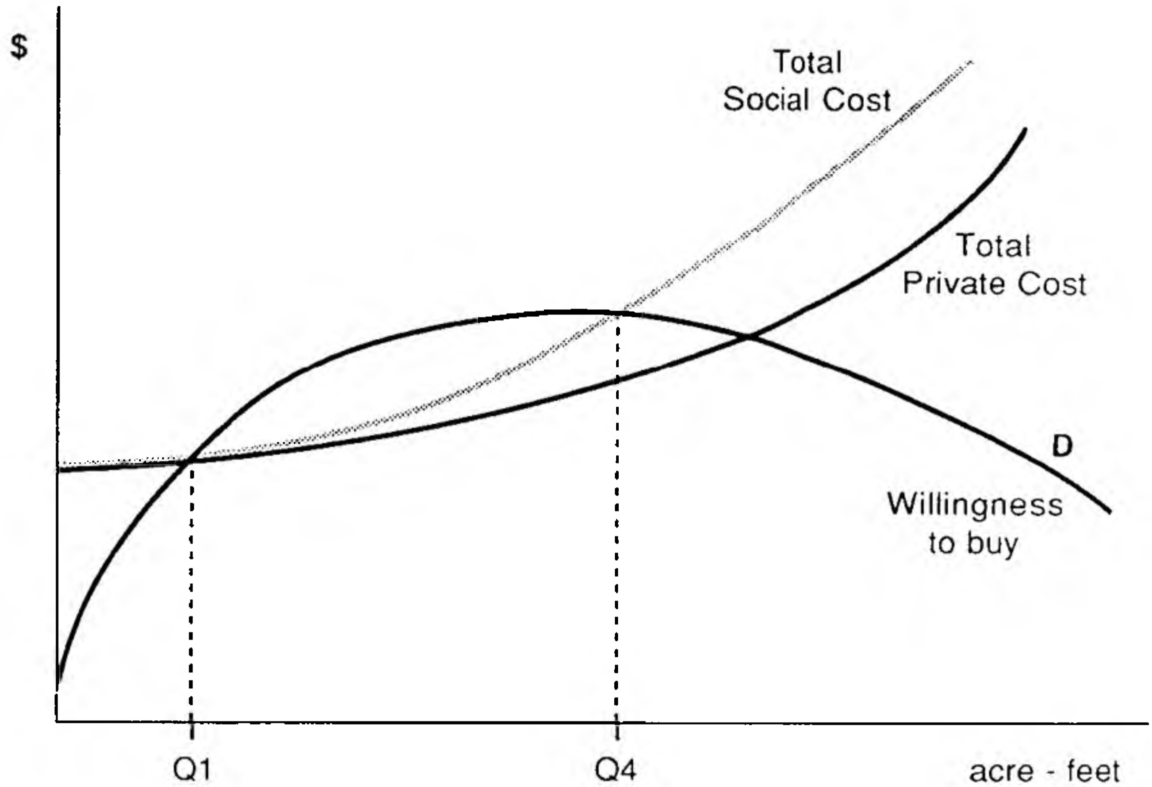


Figure 2.6 The Social Cost and Benefit Case.

2.7.3. The Lessons From Practice

Until 1983 the only water markets known to be in operation were in the United States and largely confined to those western States where the prior appropriation doctrine suited nineteenth not twentieth century socio-economic conditions. In such areas it was essential to reallocate resources to meet industrial and urban development needs, but the established rights were legally private property and could not constitutionally or politically be simply revoked by fiat. Government agencies had only two options, to buy the rights themselves or encourage market trades; both have been employed but clearly trading is a much cheaper solution.

In Britain the existence of 'licences of right', which would necessitate large compensation payments to be made if rescinded, raises the possibility that permit trading could have a role.

However, United States experience and that gained much more recently from Australia suggests that there are six specific problems which need to be addressed in operating marketable right schemes. First, unrestricted market trades are generally undesirable because traders motiviated by purely private interests ignore the impact of their activities on third parties. This is particularly crucial in the water case since the location of the abstraction can have significant consequences for 'in-situ' river users. In theory such users could themselves enter the permit markets and buy up rights in order to augment river flows; in practice their effective participation is limited. Water resource agencies would normally need to retain the power to refuse or set conditions on trades to ensure that the outcomes actually improve the net social value in use of water. The use of such powers will, of course, tend to distort the market; but the alternative suggestion that public agencies should join the market themselves to ensure socially optimal trades is hardly likely to prove acceptable to the guardians of the public purse. Restrictions on sales may also be necessary for ground water to avoid exacerbating core of depression problems.

Second, the discussed earlier ability to pay issue, has to be confronted, particularly if the companies with the greatest financial resources are monopoly buyers. This problem is highly relevant in England and Wales given the monopolistic nature of the Water Companies and currently 'inefficient' pricing practices.

Third, although active markets can improve allocative efficiency, they can be very slow in achieving such results. Moreover, it is not necessarily the case that supplies will move first from the lowest value uses. Many abstractors are not economically rational, in the sense that they are seeking to maximise profits: industrial motives are complex, including risk minimisation or simply wanting to keep 'business as usual', and in the agricultural sector maintenance of a life style may be as important as absolute profitability.

Fourth, large-scale permanent transfers from one area to another can produce significant economic side effects. Where one activity is an important source of local income and employment, the disbenefits of privately advantageous trades to local communities as a whole must be considerable. In addition if transfers reduce land values then the ratable base of an area also declines which affects the revenues of local governments.

Fifth, the whole issue of return flows can significantly complicate the permit market price setting process. Clearly the resource situation could worsen significantly if trades moved supplies from uses with high return factors to those which were consumptive (including those making returns to estuaries or the sea). Theoretically, this problem can be 'solved' by applying 'locational' weights or consumptive weights to traded prices, but once this has to happen the simplicity and low information advantages of permit trading are greatly diminished. In practice, water resource agencies have tended to try and address this problem by limiting the scope for cross-purpose or out of area trades. However, such limitations are also clearly designed to protect particular interest groups and deflect political opposition to trades. Moreover, the efficiency advantages of trading are inevitably reduced.

Finally, a problem which emerged strongly from the Australian literature - the existence of sleeper licences - has relevance in England and Wales. It was found that the lure of trading profits encouraged those licence holders with unused, or partially unused, entitlements to sell them or, under annual trading schemes, to sell the water itself. Inevitably, the purchasers did make use of the entitlement and so exacerbated scarcity problems. Where abstractions are metered it would be possible to allow only actually utilised proportions of licences to be traded, but this provision would raise political reaction from licence of right holders.

2.7.4. Permit Auctions

All permit trading schemes actually implemented protect the interests of established entitlement holders, giving them a potentially valuable asset and in a sense discriminating against emerging and possibly higher value water users. This feature, and the slowness of market trades to effect an efficient allocation of available resources, has led some analysts to suggest that trading should only be allowed after a wholesale reallocation of rights has been achieved through a permit auction. While auctions would clearly tend to transfer supplies rapidly to the highest value uses (subject to buyer monopoly and ability to pay problems) the political feasibility of using auctions to reallocate existing supply capacity is minimal. More opportunity for their use could arise when new supply increments have been made available, but practical experience of the operation of auctions is too limited to make judgements about their effectiveness vis-a-vis an allocation system based on reasonably efficient unit pricing schemes.

2.8. Potentially 'Optimal' Market Based Allocation Systems

Our review of the theoretical literature and overseas experience suggests that an increased use of market tools could act to improve the efficiency with which water is allocated. They will, however, not replace the more conventional 'command and control' systems but rather will be useful additional tools to help ensure that policy objectives are met. Which particular allocative tool is the most appropriate is highly dependent on specific socio-economic, environmental and political circumstances. The effectiveness of any tool in achieving the desired policy goals will need to be tested empirically.

If efficiency is the key management objective, unit charging schemes with the following main characteristics should be employed:-

1) three types of charge will be combined in the tariff structure - access, availability and actual usage.

2) where capacity enhancement is naturally or politically feasible, the long run marginal supply costs should be levied on the amount authorised for abstraction.

3) the bulk of these capacity charges should be imposed on peak/season water abstractions and on consumed supply units.

4) all peak water use should attract the same charge irrespective of usage pattern over the year.

5) where supplies are fixed and below demand either temporarily (drought) or of a more long term nature market clearing (or balancing) charges should be levied on actual abstraction.

6) ground water abstractions should normally attract the same price at all times of year and except where artificial recharge is occurring these should be levied on actual abstraction.

7) charges should not be based on purpose of use per se.

It would seem likely that unit pricing schemes will prove most appropriate in situations where supply enhancement is possible. However, where fixed supply limits are already evident and will remain in operation for the foreseeable future, then the tradeable permit mechanism could be an effective, more easily implemented and more politically acceptable alternative to market clearing abstraction charges. The potential for permit trading requires field investigation not only to establish whether the need to control the location of abstractions and return flow rates are major barriers to implementation but also to test the third party effects and the behaviour of potential traders (see chapters 7).

It seems highly unlikely that economic mechanisms will have a role to play in determining the allocation of resources to 'in-situ' water users, other than polluters (see chapter 5). The expectation is that desirable allocations to recreational, environmental and wildlife conservation functions will continue to be determined politically.

These general conclusions are very much based on theory and overseas experience. We turn now to our empirical work which was designed to help address the question of whether market tools can realise their potential under the conditions actually faced by the NRA.

3. AGRICULTURAL VALUE IN USE

3.1 Introduction

In this chapter attention will be focussed on the value of water in use within the agricultural sector and on the willingness of abstractors to pay for reliability. Although there is a considerable literature on the use of water in agriculture, chiefly for irrigation, rarely does this report values in use derived directly from demand curve estimation. The chief reason for this lies in the nature of the vast majority of irrigation water pricing schemes. It is still relatively common for direct abstractors to pay nothing other than a flat rate licence fee or a fixed annual service charge, even when the abstraction source is supported by storage. Where more meaningful charges are levied, it is not unusual to find that supplies are unmetered and, therefore, that prices are not volume based; for example, levies may be made per hectare irrigated (sometimes weighted by crop type) or annual fees may be charged for a proportion of the total available capacity within a particular river or storage scheme area.

Even where volume measurement occurs and volume based prices are set, the widespread practice of subsidizing irrigation development means that prices are typically low. In some cases charges simply recover operating costs; elsewhere fixed subsidies of up to 85% are given for both capacity and operating costs. Except for the French example quoted in 2.6.2, no known charging scheme is based on forward looking long-run marginal costs; at best they aim at full historic cost recovery. Such pricing practices mean that even large scale empirical exercises which have attempted to relate volume taken to price are only measuring a portion of the demand curve.

A large proportion of the evidence on value in use, therefore, comes from attempts to establish surrogate demand curve estimates. Inevitably care has to be taken in interpreting the results of such exercises since they may be more affected by the methodology employed than by the demand realities. The vast majority of such studies have been conducted in the US, Canada and Australia; the results tend to be specific to particular agronomic, climatic and economic conditions which makes their applicability to the United Kingdom extremely questionable. However, we have reviewed this literature and briefly present the salient results in section 3.2.

The much more restricted evidence from UK based studies is discussed in 3.3. It was clear at the start of the project that the extremely limited and often dated value in use estimates available for the UK, necessitated the collection of new empirical evidence. The methodology employed to gather this evidence and the results are presented in 3.4 - 3. 7. Attention is then turned to the question of reliability and the willingness of irrigators to pay for greater supply certainty. Known literature provides little guidance on this matter and one of the objectives of the field work programme was to estimate the value of changed reliabilities by assessing the actual losses made by irrigators in catchments with poor reliability, investigating the risk avoidance expenditures made by abstractors and attempts to establish the hypothetical willingness of irrigators to pay increased charges for more certain supplies. The results of this empirical research are given in 3. 9.

3.2 Overseas Evidence on Value in Use

3.2.1 Demand Estimation Methodologies

Although there are examples in the literature where large-scale cross-sectional analyses have been employed to measure the water demand curve directly, the bulk of the reported research depends on surrogate demand estimation methods. Three such methods are most commonly encountered:-

1. Controlled experiments to analyse crop-production functions for particular crops. Basically these experiments measure the dose-response relationship between the amount of water applied and crop yields under highly controlled conditions (see for example Ayer and Hoyt, 1981). The value of the additional crop yields can then be estimated using market product prices and aggregate variable cost data.

2. Farm crop budget analysis, which measures under field as opposed to experimental conditions the value of the productivity gains generated by water use or the share of total farm revenue attributable to water inputs. The total revenue generated by irrigated crop production is calculated, and the non-water related production costs are then deducted from this sum. After taking into account the costs incurred by the farmer for the actual water and taking delivery of it, the surplus (or residual) revenue represents the maximum value of the water itself. This approach can be extended to determine the changing revenue yield which occurs as the quantity of water applied is varied (Anderson 1983, Colby 1989, Gibbons 1986).

3. Hedonic price approach, this aims to infer the value of water (and/or water rights) from farm land sales and rent data (Hartman and Anderson 1962, Torell et al 1990).

It must be stressed that the use of these various techniques means that the reported results of the research need not be comparable. Moreover, it is necessary to take account of the degree to which the results apply to irrigation on individual, representative farm types or in aggregate within and across water districts. Aggregate results can disguise very major differences in individual responses.

3.2.2 Summary of Overseas Results

As expected the demand curves and the responsiveness of demand to price changes varies considerably, depending on crop type, climatic regime, economic conditions and soil type. According to Tate (1990) the demand curve most commonly revealed for irrigated water is "kinked", with a steep, rapidly falling (ie inelastic) portion at high water price levels and a much shallower (ie elastic) portion at lower price levels (Figure 3.1).

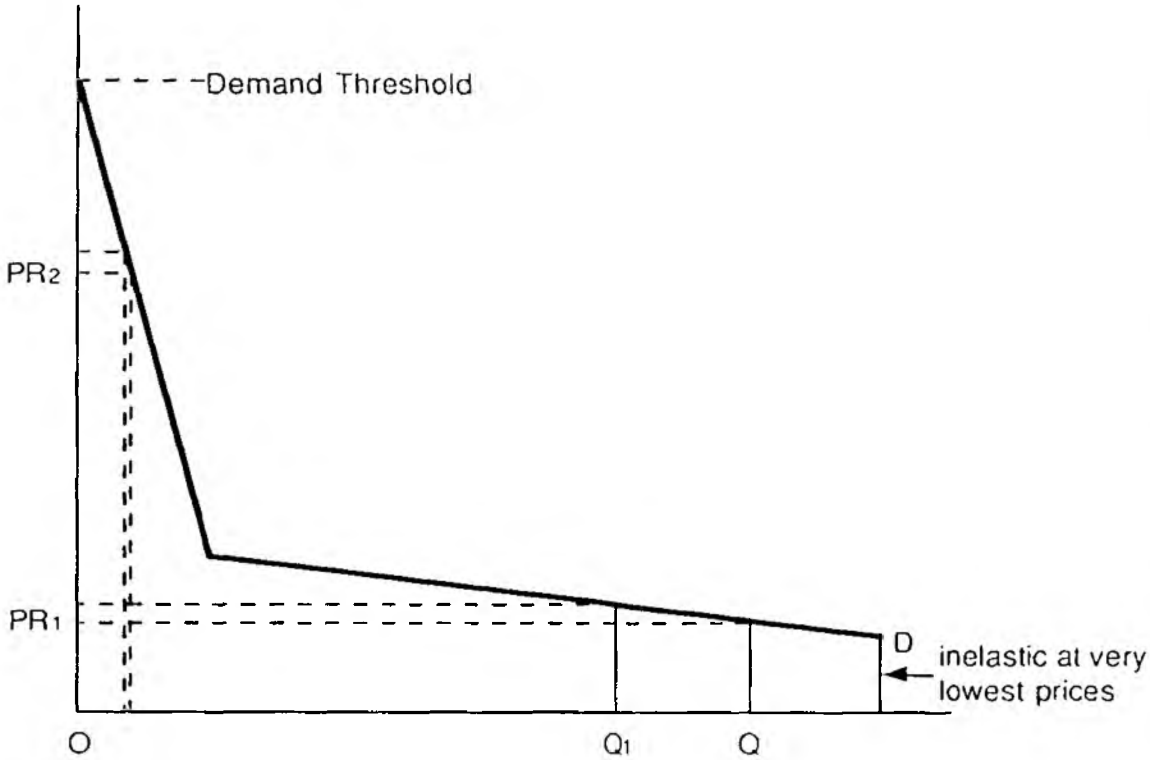


Figure 3.1 "Kinked" Demand Curve

This means that when water prices are below the "kink", considerable water savings (Q_1 - Q) can occur from relatively small price rises, but above the kink price rises have limited impact on the quantities taken until the demand threshold is reached. This threshold simply represents the point at which the price exceeds the value of all irrigated output and demand for water plunges to zero. It is also possible that another kink or step occurs at the very lowest price levels; when water is so cheap it simply becomes an irrelevance in production decision making - the same quantity is employed irrespective of price.

Clearly if stepped curves are widely applicable then it becomes crucially important to know which part of the demand curve is in operation when considering the results of research studies. Unfortunately such knowledge is rarely available. Therefore reported average willingness to pay estimates need to be treated with caution, as do average price elasticity‡ measures.
Although 'kinked' curves of the type shown in Figure 3.1 may be typical for individual or groups of similar farm enterprises, studies which have considered aggregate demands suggest that the total demand for irrigation water might be rather different. Table 3.1 summarizes the evidence on aggregate price elasticities obtained from various cross-sectional studies conducted in the United States, where different water districts charge different prices. In other words they are attempts to measure demand directly from observed price-quantity relationships. These studies show clearly that aggregate demand becomes more responsive to price as prices rise. Whereas at low and average prices elasticities are typically below 1, at high prices the elasticity can be over 2, which means a 10% increase in price would result in a 20% fall in the quantity of water used. At low prices farmers are encouraged to irrigate crops where the yield gains are small. As prices become more significant some farmers and products reach the demand threshold, they move out of irrigation and thus in total the curve becomes more elastic. However, it must be noted that it is possible that the studies have only captured a portion of the total curve, since during the 1960s and 1970s water prices were typically highly subsidised.

AUTHOR	AVERAGE ELASTICITY	LOW-PRICE ELASTICITY	HIGH-PRICE ELASTICITY	AREA STUDIED
MOORE	-0.65	-0.14	-1.58	SAN JOAQUIN (LINEAR REG)
MOORE/HEDGES	-0.65	-0.19	-0.70	SAN JOAQUIN (QUADRATIC REG)
BAIN/CAVES/ MARGOLIS	-0.64			34 CALIFORNIAN WATER DISTRICTS
HEADY ET AL	-0.37	-0.17	-0.56	17 US WESTERN STATES
SHUMWAY ET AL		-0.56	-2.32	CALIFORNIA (2 EQU. MODEL)
SHUMWAY ET AL		-0.48	-2.03	CALIFORNIA (1 EQU. MODEL)
HOWITT/ WATSON/ADAM	-0.97			CALIFORNIA (LINEAR PROG)
HOWITT/ WATSON/ADAM	-1.50			CALIFORNIA (QUAD. PROG.)

Table 3.1 Cross Sectional Price Elasticity Estimates

Table 3.2 summarizes the values for water derived from a variety of research projects which employ surrogate demand measures. Given that all the studies have been undertaken in climatic and socio-economic conditions remote from those occurring in Britain, the actual value figures are of little relevance. However, they do reveal two potentially useful points. First, the range of values is exceptionally wide. This suggests that any attempt to use price to manage irrigation demand within particular over abstracted (or supply limited) catchments will need to be accompanied by area and crop specific studies in order to ensure that the required supply/demand balance is actually achieved. Second, some of the values are exceptionally and rather unexpectedly high. It has commonly been assumed that agricultural values in use are relatively low, in which case full marginal cost pricing and tradeable permit systems would tend to move water from agricultural to urban and industrial purposes. For some crops, particularly vegetables and fruit, it seems clear that this assumption need not be valid. High values in use also suggest that the potential income losses from water shortages could be very high for at least some farm enterprises.

Table 3.2 Summary of Overseas Value in use for Irrigated Agriculture.

METHOD	SOURCE	COUNTRY	YEAR VALUES BASED ON	CROP	VALUE	PRICE	QUANTITY DEMANDED	VALUE OF LOSS
CROP WATER PRODUCTION FUNCTION	AYER AND HOYT (1981)	U.S.A	1980	COTTON	C$54 PER ACRE INCH ($64.80 PER MEGALITRE)			
FARM CROP BUDGET ANALYSIS	MULLER (1985)	CANADA	1984		C$ 36 PER MEGA LITRE			
	CRADDOCK (1981)	CANADA	1981			C$0-0.48	1,967 ACRE INCH (2360 MEGALITRES)	
						C$7.20	ZERO	
	MARTIN AND SNIDER (1979)	U.S.A	1979	SORGHRAM	US$33 PER ACRE FOOT (US $39.60 PER MEGALITRE)			
				LETTUCE	US$157 PER ACRE FOOT (US$188.4 PER MEGALITRE)			
				DRY ONIONS	US$1280 PER ACRE FOOT(US$1536.0 PER MEGALITRE)			
	BUSH AND MARTIN (1986)	U.S.A	1984	ALFAFA	US$38 PER ACRE FOOT (US%45.6 PER MEGALITRE)			
				COTTON	U.S$133 PER ACRE FOOT (US$159.6 PER MEGALITRE)			
	LONG (1987)	U.S.A	1982	IRRIGATED VEGETABLE				U.S$750-1500 P. ACRE FOOT (US 900-1800 PER MEGALITRE)
	LONG (1991)	U.S.A	1991	ALFAFA	US$0-240			
HEDONIC PRICE	COELLI ET AL (1991)	AUSTRALIA (NORTHEN REGION)	1989		AUS $23,566 (PER FARM)			
		AUSTRALIA (LAKES REGION)	1989		AUS $84,123 (PER FARM)			
	TORELL ET AL (1990)	U.S.A	1990		ADDS 30-60% TO VALUE OF FARM			
		NEW MEXICO	1988		US$9.50 PER ACRE FOOT (US$ 11.4 PER MEGALITRE)			
		OKLAHOMA	1986		US$1.09 PER ACRE FOOT (US $1.308 PER MEGALITRE)			

3.3 Evidence on Value in Use for England

3.3.1 Crop Water Production Functions from Controlled Experiments

The Agricultural Development and Advisory Service (A.D.A.S.) of the Ministry of Agriculture has conducted a number of experiments which relate crop yields to the quantity of irrigation water employed and to the timing of irrigation. Such experimental data can then be employed to calculate the gross margins derived from water applications. The gross margin is defined as the gross revenue obtained from the sale of the additional crop output minus any variable costs incurred in producing, harvesting and marketing the output. Such gross margins give a crude estimate of the value in use of the irrigation water employed in

	AVERAGE YIELD RESPONSE TON/ACRE INCH	PRICE £/TON	GROSS MARGIN RESPONSE £/ACREINCH
CEREALS	0.18	90	16.20
GRASSLAND DAIRY	0.25	285	11.50
GRASSLAND BEEF	0.25	130	4.50
PEAS VINING	0.40	110	38.40
PEAS DRIED	0.40	120	48.00
POTATOES EARLY	0.80	150	111.00
POTATOES SECOND EARLY	0.80	70	47.00
POTATOES MAIN CROP	0.80	50	35.80
SUGAR BEET	1.3	21.20	25.00
BROAD BEANS PROCESSING	0.40	175	64.00
BEANS FRENCH FREEZING	0.60	86.00	42.00
BEANS RUNNER	0.50	225.00	53.00
SPROUTS EARLY	0.40	140	32.00
CABBAGE SUMMER	1.40	100	87.70
CARROTS EARLY	0.30	100	20.00
CAULIFLOWER SUMMER	100	1.50 (CRATE)	76.20
LETTUCE DRILLED	100	1.50 (CRATE)	46.50
ONIONS	0.80	60	19.00
APPLES COX	0.15	0.195/Kg	34.00
BLAVKCURRENTS FRESH	0.30	0.65/Kg	119.20
BLACKCURRENTS PROCESSING	0.30	325	67.50
RASPBERRIES FRESH	0.25	0.75/Kg	73.00
STRAWBERRIES FRESH	0.25	0.45/Kg	46.10
STRAWBERRIES PROCESSING	0.25	250	37.50

Table 3.3 Irigation Crop Responses and Additional Gross Margins.

situations where the capital investment in irrigation systems has already been made. The results from such exercises are of a highly aggregate nature, with no account taken of the variable physical yield responses obtained for different soils and seed varieties, the range of variable costs incurred by farmers and the different prices obtained for products. In addition, the capital and operating costs involved in obtaining the water supplies are omitted.

Table 3.3 gives the results from a 1977 ADAS study as reported in Lingard 1980. Clearly movements in product prices and variable input costs since 1977 could have materially altered the details of these financial results. It does however, serve to illustrate that the return from irrigation can be considerable for some crops, most obviously early potatoes, soft fruit and some vegetables. However, it has to be borne in mind that farmers aiming for specific qualities and sizes of crop will not necessarily irrigate to obtain maximum physical yield. The low gross margins recorded for irrigation of grassland would seem to indicate that irrigation is uneconomic; this result can be misleading since no account has been taken of the costs of alternative animal feed if silage/hay is not available and if stock has to be kept off the fields for longer periods. Further, it has to be noted that the physical yield responses are obtained under dry year conditions which serves to inflate the apparent value in use of water in normal/wet years. This has implications for the viability of irrigation when charges are levied on authorised as opposed to actually abstracted quantities. The real value to the farmer of an authorisation will be reduced to take account of all years when payments are made for supplies which are not required. Although this factor will apply to all crop output to some extent, it is particularly important for early crops (potatoes and other vegetables) where in practice irrigation is rarely employed except in abnormally dry winters and on exceptionally dry, sandy soil. Finally, it is worth pointing out that whenever product prices contain a direct subsidy element or are artificially kept above competitive market prices, then the private water value could diverge quite markedly from its social value.

Later 1988 ADAS work is reported in Hinton and Varvarigos 1990. Table 3.4 gives the results of this study and shows that in value of output terms soft fruit, potatoes and some other vegetables give the highest response to irrigation. It should be noted that these product values and thus the imputed water values are not comparable with the gross-margins recorded on table 3.3 since they ignore the additional variable costs of producing, harvesting and marketing the extra output. The real water values are thus inflated and the figures at best provide some guidance on the maximum short run value of irrigation for different crop types. Water values in the longer term would be considerably less since both the capital costs of irrigation and the reduced value of irrigated output in wet years would have to be taken into account.

	WATER APPLIED DRY YEAR. ACRE-INCH	AVERAGE YIELD RESPONSE TON/ACRE/INCH	VALUE (1988) £/TON	RESPONSE VALUE
CEREALS	1	0.182	110	20.20
GRASSLAND DAIRY	6	0.253		
GRASSLAND BEEF	3	0.253		
PEAS VINING	1	0.405		
PEAS DRIED	1	0.405	180	72.90
POTATOES EARLY	3	0.809	120	97.08
POTATOES SECOND EARLY	5	0.809	100	80.90
POTATOES MAIN CROP	6	0.809	80	64.72
SUGAR BEET	5	1.316	29	38.16
BEANS BROAD PROCESSING	2	0.405	180	72.90
BEANS FRENCH FREEZING	2	0.607	90	54.63
BEANS RUNNER	2	0.506	225	113.88
SPROUTS EARLY	3	0.405	140	56.70
CABBAGE SUMMER	3	1.417	100	141.70
CARROTS EARLY	3	0.304	100	30.40
CAULIFLOWER SUMMER	2	100 CRATES	1.5	150.00
LETTUCE DRILLED	2	100	1/ CRATE	100.00
ONIONS	4	0.809	80	64.72
APPLES COX	4	0.152	30p/Kg	46.33
BLACKCURRENTS FRESH	3	0.304	65p/Kg	200.77
BLACKCURRANTS PROCESSING	3	0.304	65p/Kg	200.77
RASPBERRIES FRESH	3	0.253	1/Kg	257.06
STRAWBERRIES FRESH	3	0.253	60p/Kg	154.23
STRAWBERRIES PROCESSING	3	0.253	250	63.25

Table 3.4 Crop Response Revenue and Revenue Increment.

3.3.2 Farm Crop Budget Analysis

As described in 3.2.1, farm crop budget analysis involves field surveys of farms employing irrigation; the results are, therefore, highly dependent on the size of the sample, the nature and location of the farms surveyed, and on the economic, agronomic and climatic conditions operating at the time of the survey. Such studies, however, can provide useful additional information from which to impute water values, particularly on the capital and operating costs associated with irrigated agriculture.

Although a number of small scale analyses employing the crop budget methodology have been conducted, most are highly dated (eg Lingard, 1980) and known recent work is confined to those by Hinton and Varvarigos (1990) and the University of Newcastle (Anglian Water/NRA 1990).

Hinton and Varvarigos give an economic assessment of irrigation in the Eastern counties of England based on a survey of 23 farms in the 1985 crop year. Its sample farms are classified into four groups according to the level of capital investment in irrigation equipment (high: £170,000 - £200,000; medium: £80,000 - £100,000; lower: £30,000 - £60,000 and low: under £10,000). Further disaggregation based on the type of equipment and application methods is also made. Inevitably, the disaggregation process means that some of the calculations are based on the results from a single farm and thus the general applicability of the findings will critically depend on how representative that farm actually is. Bearing in mind this caveat, the work suggests that at 1989 values, the high capital system involve annual costs (depreciation, interest and operating) of some £130 to £270 per irrigated acre or £55 to £78 per acre inch (£550-£780 per megalitre). Medium capital systems incur costs of between £130 to £180 per acre or £73 - 74 per acre inch (£730-£740 per megalire). Low capital systems show wide variations in the per acre inch costs, varying from £30 to £160 (£300-

£1600 per megalitre). Given these variations the suggested average annual cost of irrigation of £90 per acre inch (£900 per megalitre) must be viewed with some caution.

When rates of return on capital invested were calculated‡‡, these were found to vary markedly both between capital cost groups and within such groups. For example, within the high capital class, values ranged from - 13.8% (linear boom hose reel system for beans, potatoes and onions) to 26.4% (centre pivot for a mix of field crops), while in the low investment category the results indicated an extremely wide range of returns from - 40.3% (hose reel rain gun for potatoes) up to 634.1% (a fixed frost protection system for blackcurrants). The range of results obtained strongly suggest that considerable care needs to be taken when calculating the value generated by irrigation water. Clearly there is no one value in use.

Hinton and Varvarigos also examine the margins obtained from irrigation of different crops over the sample farms. The margins are defined here as the revenue from the additional crop yield minus the costs of operating the irrigation system (including the payments made for the water itself). By calculating margins in this way the real value of the additional output (and thus of the water) is inflated since no account is taken either of the other variable input costs involved in producing and marketing the extra yield or of the capital costs. Table 3.5 summarises the results obtained and gives the imputed (but inflated) water value in use. The figures suggest that highest values in use are obtained for crops such as brassicas, potatoes, blackcurrants, beans and onions, but returns are low for cereals, sugar beet and oilseed rape. It has, however, to be noted that few farmers would attempt to establish irrigation systems specifically for such low return crops. These crops are usually only given one application of water to either establish the crop, or "get into ear" (prior to harvest). Any additional outputs are

	POTATOES	ONIONS	SUGAR BEET	WHEAT	BARLEY	OIL SEED RAPE	BRASSICAS	SPROUTS	BEANS	STRAWBERRIES	CANE FRUIT	BLACKCURRENTS
NUMBER OF CASES	22	10	10	9	5	2	4	3	4	2	2	2
CROP HA.	821	328	365	965	252	9.3	18	73	56	12	10	87
IRRIGATED CROP HA.	714	303	270	275	206	72	12	55	56	12	10	79
PROPORTION IRRIGATED %	86.9%	93.4%	74.1%	28.5%	81.6	77.1%	67.4%	76.3%	100%	100%	100%	[illegible]
HECTARE MILLIMETERS APPLIED	51,030	14,975	16,838	5,873	7,989	2,167	263	2,177	1,640	600	500	9,902
APPLICATION (HA MM)	72	50	62	22	40	30	23	40	30	50	50	125
OPERATING COST £/HA MM	2.60	1.30	1.10	1.00	1.1	1.20	3.0	1.30	1.50	1.80	1.20	1.10
OUTPUT INCREASE	7740	1,819	2,462	263	272	35.6	61	153	48	32	15	621
EXTRA TONS PER HA	10.8	6.0	9.1	0.9	1.3	0.5	3.0	2.8	0.9	2.7	1.5	[illegible]
AVERAGE PRICE £/TON	65	88	27	100	111	280	248	280	449	89	[illegible]	[illegible]
INCREASE IN REVENUE £	503,352	159,184	66,485	26,16[illegible]	30,159	9,959	15,144	42,900	21,535	2,862	[illegible]	[illegible]
EXTRA REVENUE/HA	705	525	246	95	146	138	1,262	780	385	239	316	1,760
EXTRA REVENUE/HA MM	9.9	10.6	3.9	4.5	3.8	4.6	57.60	19.70	13.1	4.8	6.3	14.0
MARGIN OVER OPERATING COST	372,388	139,030	47,362	20,291	21,031	7,349	14,360	40,106	19,082	1,754	[illegible]	125,855
MARGIN £/HA	522	459	175	74	102	102	1,197	729	341	146	255	1,626
MARGIN £/HA MM	7.3	9.3	2.8	3.5	2.6	3.4	54.6	18.4	11.6	2.9	5.1	13.0

Table 3.5 Crop Margin Generated Over Operating Cost.

regarded as a pure bonus since the irrigation system and authorised water are already available. Increases in the price of water per actual abstraction quantities could result in such crops being taken out of irrigated agriculture.

The farm crop budget methodology was also employed by the University of Newcastle in the study of the factors driving the demand for irrigation by farmers in the Middle Level catchment within the Anglian region. The central question addressed by this study concerns the way irrigation use will change in the future in relation to changes in the Common Agricultural Policy. Although some value in use information can be deduced from this work, the results are highly specific to the Middle Level, with its Grade 1 agricultural land, highly water retentive soils, considerable specialisation in potatoes and intensive agricultural practices. The figures cannot be generalised to other areas even within East Anglia. Representative models were developed using a linear programming technique for three farm types (150 ha mixed cropping with potatoes and sugar beet; 60 ha mixed cropping mainly cereals and potatoes, and a 10 ha specialist horticultural unit). The linear programme models were based on the assumption that farmers will attempt (and have the ability and knowledge to do so) to maximize their gross margins (ie the difference between gross revenue and variable costs). A yield response model, covering a 25 year period and allowing for a range of levels of water application was employed to calculate the benefits yielded by investment in irrigation systems. It has to be noted that in these calculations 1977 ADAS data is employed to estimate the costs of irrigation equipment and Nix (1988) was used to calculate labour costs. These cost figures are aggregate values, this may significantly distort the results since as Hinton and Varvarigos (1991) clearly demonstrated actual capital operating costs vary greatly with the type of equipment employed. Table 3.6, which gives the value in use (or the willingness of farmers to pay for additional water to increase the irrigated area) as determined by the Middle Level study, must therefore be viewed with caution.

Although the study argues that the demand for water is unlikely to change radically as a result of CAP variations, two of the results do in fact suggest that the impact could be significant in particular localities. Even under the scenario which deals with a 20% cut in potato quota, the possibility is raised that this will

FARM SIZE (HA)	WATER AVAILABILITY HA MM	TOTAL GROSS MARGIN £	DUAL PRICE FOR WATER £/HA MM
60	0	64,061	18.24
60	3,000	72,051	0
150	500 STORED	69,989	11.88
150	500 SUMMER	69,989	11.22
150	0	135,422	18.24
150	10,000	153,814	0

Table 3.6 Willingness to Pay; Linear Programming Solutions.
Source: NRA-Newcastle Report (1990).

result in increased intensity of production on the reduced quota acreage. It could imply an increasing demand for irrigation water. Likewise the finding that a reduction in the gross margins for cereals results in land being re-allocated to vegetables and soft fruits might also produce significant local demand increases for water, particularly when farmers employ supplies to meet output quality requirements and to reduce risk (see 3.9). The Middle Level study indicates that in real terms the benefit from irrigation, taking into account the cost of capital employed, is low. The calculations are, however, based on the potato acreage only, assume a 14% rate of interest, and do not take account of quality improvements (and therefore product price increase) achieved by irrigation. It also should be noted that the benefits are calculated from the viewpoint of the economy as a whole. Tax concessions and equipment grants were omitted, but these can substantially reduce the cost of irrigation for the individual farmer and thus affect his investment decisions.

Table 3.7 Summary of the UK Value in Use Data for Irrigated Agriculture

METHOD	SOURCE	COUNTY	YEAR VALUES ARE BASED ON	CROP	DUAL PRICE WATER	ANNUAL COST OF IRRIGATION	RESPONSE VALUE £/ ACRE INCH	GROSS MARGIN VALUE £/ ACRE INCH	OPERATING COST	VALUE AT THE MARGIN
LINEAR PROGRAMMING	NEWCASTLE UNI REPORT TO NRA ANGLIAN REGION (1990)	MIDDLE LEVEL	1989		£11.24					
					£11.88					
					£11.22					
					£18.24					
FARM CROP BUDGET	HINTON AND VARVARIGIOS (1990)	EASTERN COUNTIES	1989			£160 PER ACRE				
						£108 PER MEGALITRE				
		EASTERN COUNTIES	1989 VALUES; 1985 CROP RESPONSE	BRASSICAS					£34	£455 +
				BLACKCURRANT					£12	£750 +
				POTATOES					£29	£305 +
				SPROUTS					£34	£300 +
				ONIONS					[illegible]	£170 +
				BEANS					£17	£160 +
	ADAS (1988)	EASTERN COUNTIES		MAIN CROP POTATOES +			£64.72			
				RUNNER BEANS +			£113.85			
				CAULIFLOWER +			£150.00			
				ONIONS +			£64.72			
				BLACKCURRENTS +			£200.77			
				CEREALS +			£20.02			
				SUGAR BEET +			£38.16			
	ADAS (1977)			MAIN CROP POTATOES				£35.80		
				RUNNER BEANS				£53.00		
				SUMMER CABBAGE				£87.70		
				ONIONS				£46.00		
				BLACKCURRENTS				£119.20		
				CEREALS				£16.20		
				SUGAR BEET				£25.00		

3.3.3 Summary Points from UK Evidence

Table 3.7 attempts to summarize the value in use of water imputed from the UK data. The figures are not strictly comparable; all inflate the apparent values by neglecting some cost elements, all are difficult to generalize, and all are essentially static with respect to climatic variables and previous product market conditions. It is most important to note that the studies are measuring two different values in use. The first set (marked by an +) adopts a short run perspective by ignoring the cost of investment in irrigation, while the second group attempts to measure the profitability of investment in irrigation equipment and thus the longer term value in use. In the latter case, profitability will crucially depend on the prevailing weather conditions following such an investment; this will be most marked during periods of high market interest rates. Investment demand, and therefore the demand for abstraction licences, may have more to do with farmers' expectations about the future prevalence of drought than about the past financial viability of irrigation.

The UK evidence does tend to suggest that the short run value in use for irrigation water can be high for a range of crops. The Hinton and Varvarigos study also indicates that even when the costs of capital are taken into account there are high returns from some crop and irrigation equipment combinations. However, both this latter study and the work on the Middle Level farms makes it clear that in real terms the long run profitability of irrigation (and thus the value in use of the water) can be low or even negative. If unit water prices rise the expectation would be that margins would decline and low margin crops would move out of irrigation agriculture. However, both the UK and overseas data suggests that there is considerable inelasticity of demand for irrigation water. Clearly, in the very short run, when the growing season is already underway, demand tends to be very unresponsive to price particularly in dry years when losses in crop quantity and quality could drastically reduce revenue. Only in the medium term are changes in irrigation efficiency, crop mix and area under irrigation really feasible. But even medium term responsiveness may be relatively slight while extant irrigation equipment remains operational. Given the sunk nature of investment costs, very dramatic unit price rises could be necessary to get to the demand threshold for some crops (see figure 3.1). Indeed there is some evidence that higher water prices could act to locally increase water demand per acre if farmers shifted to more intensive production of high return crops. These short and medium term inelasticities have obvious implications for the NRA's use of unit price as a demand management tool, and strongly suggest that their use would have to be accompanied by some form of physical abstraction limitation to cope with limited supply situations.

It has been stressed previously that available UK value in use data is limited; the results cited are, at best, broadly indicative of the range of values encountered for agricultural businesses. Importantly, although a number of the studies do mention the importance of irrigation to farmers as an insurance strategy against risk and uncertainty, there are no known estimates which attempt to assess the insurance value of water and the willingness of farmers to pay for supply security. In view of the relative dearth of contemporary UK data, this project involved an attempt to generate new information through a study of the Anglian region.

3.4 The East Anglian Farm Survey

3.4.1 Methods of Data Collection and Analysis

As discussed in 3.2.1 three methods of obtaining surrogate water demand/value data have typically been employed in the agricultural case - controlled experiments involving field trials, farm budget analyses and hedonic pricing. An alternative potential method, contingency valuation, has been widely used to estimate values for amenity and recreational resources, but no known study has applied this approach to the use of abstraction water for agricultural purposes. Contingency valuation simply means that consumers are questioned about their willingness to pay for additional quantities or improved qualities of goods and services. The resultant values are always somewhat hypothetical (or contingent) since the consumers' real reactions to changed prices or supply conditions may be somewhat different from those expressed under 'armchair' conditions. While recognising this potential defect inherent in the valuation methodology, it was nevertheless felt that it was the only feasible method to give some insights into:-

(a) farmers' willingness to pay for different reliabilities of supply,

(b) their potential responses to alternative supply and demand management scenarios, including the restriction or removal of authorisations and the introduction of tradeable permit systems.

Controlled experimentation was clearly inappropriate for this study, but it was possible to employ, to varying extents, all three of the alternative approaches. A personal questionnaire survey of farm businesses was conducted, the objective of which was to elicit both the value of irrigation water from farmers' observed management practices and from their contingent responses to alternative hypothesised scenarios. Data was also obtained from secondary sources on the gross margins achieved by different types of farm enterprise from a range of crops. Such data could then be integrated with information derived from the farm survey on actual irrigated acreage, the crop mix and the capital expenditure on storage and irrigation facilities to provide a range of value in use estimates. Further information, albeit of a somewhat restricted nature, was also gathered on the value of an abstraction licence as measured by differential land values and by the farmers' contingent willingness to pay a premium for 'with licence' land.

3.4.2 The Farm Sample

The sample frame consisted of all agricultural businesses possessing NRA Abstraction Licences within the NRA Anglian region. For the over abstracted catchments of the Cam and Rhee the total population (agricultural and industrial) were included in the survey. Elsewhere in the region the sample frame was stratified into two groups according to the availability or otherwise of water storage facilities.To establish a sample of farms with water storage facilities the following initial licence parameters were defined:

Winter only licences;
Primary use spray irrigation;
Abstraction from surface water;
Over 10 t.c.m.a.
Issued since 1984.

A computer search of the NRA Anglian Region Abstraction Licence files generated a sample of farms from within the region possessing water storage facilities (lined reservoirs, catchpits or impounding facilities). However, this lead our sample to be dominated by large farms and farm businesses holding multiple licences, thus in order to include all farm types we relaxed the size criteria. Discussion with the Area Hydrologists at the Northern, Central and Eastern regional offices helped us select catchments where water availability was becoming a problem. In the Northern and Central areas, they also provided us with details of those farms in the process of applying for permission to install storage facilities.

To establish a parallel set of farms without water storage facilities a more "ad hoc" selection procedure was adopted. Ideally a set of "shadow" farms of a similar size, abstraction type and location on the catchment to those farms with storage facilities was required. However, this was not possible due to the predominance within these catchments of farms with storage. This of course reflects local hydrological conditions. Thus the selection of shadow farms was less catchment based, but we did attempt to select farms within neighbouring catchments.

After piloting and slight amendment as a result of irrigator reaction, the questionnaire, reproduced as Appendix 1, was administered to a total of 72 farm enterprises out of a total of 133 originally chosen for contact. The questionnaire surveys took place between August and mid-November, by which time it was judged that the costs of prolonging the attempt to secure additional interviews outweighed the benefits of a marginal increase in final sample size. Table 3.8 summarizes the regional breakdown of the surveyed concerns, while Table 3.9 gives details of their licence characteristics.

	TOTAL	CAM + RHEE	NORTHERN	EASTERN	CENTRAL
SAMPLE FRAME	133	24	32	47	30
REFUSALS	11	4	2	5	0
UNABLE TO TRACE	33	5	1	18	9
UNABLE TO ESTABLISH INTERVIEW DATE	17	1	9	7	0
ACTUALLY INTERVIEWED	72	14	20	17	21
SUMMER ONLY LICENCE	23	8	4	3	10
STORAGE	49	6	16	14	11
STORAGE CAPACITY					
UNDER 25 MEGALITRES		3	9	12	2
25-50 MEGALITRES		3	6	1	6
OVER 50 MEGALITRES		0	1	1	3

Table 3.8 Farm Survey, Regional Breakdown.

The majority of surveyed firms held multiple abstraction licences, with authorisations of various types. Despite recent NRA policy to restrict new licences to winter only, summer licences were still the most common within the sample. Licence details were collected from NRA records, but as part of the survey questionnaire, farm managers were asked if they knew the conditions of their authorisation. 15 out of the 72 were unable to recall any conditions and had apparently little understanding of either the unit water cost variations which occurred, depending on abstraction period, or of the security differences between renewable licences and licences of right. Such lack of knowledge must affect the abstractors' behaviour and possibly their ability to respond 'rationally' to any attempts by the NRA to influence behaviour through unit abstraction charges. Actual abstraction data was collected from the farmers themselves and is clearly subject to error, particularly where use is unmeasured and 'guestimates' are made based on capacity of the irrigation equipment.

PART A:	LICENCED VOLUME	ACTUAL VOLUME
0.1-20	33	50
20.1-40	16	9
40.1-60	6	2
60.1-80	3	2
80.1-100	4	4
100.1-120	2	2
120.1-140	2	1
140.1-160	3	1
160.1-180	0	0
180.1-200	2	0
NOT APPLICABLE*	1	1
	72	72

*One farm used water for domestic use only.

PART B:	
WINTER ONLY LICENCE	2
WINTER ONLY LICENCE PLUS SUMMER LICENCE OF RIGHT	31
WINTER ONLY LICENCE PLUS SUMMER RENEWABLE LICENCE	16
WITH STORAGE	49
SUMMER ONLY LICENCE PLUS ALL YEAR LICENCE OF RIGHT	2
SUMMER ONLY LICENCE PLUS ALL YEAR RENEWABLE LICENCE	2
SUMMER ONLY LICENCE OF RIGHT	11
SUMMER ONLY RENEWABLE LICENCE	8
WITHOUT STORAGE	23
TOTAL	72

Table 3.9 Farm Survey Licence Details.

As Table 3.9 indicates, the majority of the farm businesses held a licence or licences which authorised abstractions of below 40 megalitres per annum, although the sample did include large abstractors, including two who were authorised to take nearly 200 megalitres. Not unexpectedly, actual abstractions were below authorised; limited flow availability for "run of river" summer abstractors, and temporary licence suspensions in some catchments were added to the normal tendency for less than full entitlements to be taken. Storage facilities were available on 49 of the surveyed farm businesses; all winter only licence holders automatically had storage. It appears evident, since all but two winter licence holders also have summer licences, that storage is being employed both to increase absolute availability and also to cope with the unreliability of summer flows. Somewhat unexpectedly, very few all year licences emerged in the sample, and none of these had storage facilities. In two of these cases farms were abstracting from groundwater sources and using that water for domestic as well as spray irrigation. One farm used the groundwater sources for purely domestic use,even though the licence indicated spray irrigation use. The remaining farm, again abstracting from groundwater sources, used the supply for frost protection and spray irrigation of fruit trees.

LAND USE	AREA OCCUPIED (HA)	%
ARABLE / HORTICULTURAL	29268.81	92.73%
PERMANENT PASTURE	1837.00	5.82%
FRUIT	293.29	0.93%
OTHER	163.36	0.52%
TOTAL UTILISED AREA	31562.46	100%
TOTAL AREA OCCUPIED	27783.01	

Table 3.10 Land Use in the Farm Sample. Note: Total Utilised area is greater than the Total Occupied area, due to Multiple-Double Cropping.

Table 3.10 and 3.11 give the salient details about land use allocations and the proportions of each crop produced with irrigation As anticipated given the area of study, the sample was dominated by farm businesses specialising in arable and horticultural enterprises. In terms of the total area under irrigation, potatoes were the dominant crop, but it has to be noted that several high value salad crops

Table 3.11 Land Allocation to Crops

ENTERPRISE	TOTAL AREA (HA)	TOTAL AREA IRRIGATED (HA)	PROPORTION OF CROP AREA IRRIGATED (%)	PROPORTION OF TOTAL IRRIGATED AREA
MAIN POTATOES	1552.04 (40)	1424.47 (36)	91.78	29.50
SUGAR BEET	3022.74 (44)	797.85 (27)	26.00	16.52
LETTUCE	524.22 (4)	483.57 (2)	92.20	10.01
ONIONS	403.47 (14)	345.22 (12)	85.00	7.15
EARLY POTATOES	288.34 (12)	262.39 (11)	91.00	5.43
CELERY	254.34 (2)	243.00 (1)	95.00	5.03
CARROT	342.22 (6)	173.02 (5)	50.00	3.58
APPLE	162.80 (5)	162.80 (5)	100.00	3.37
WINTER WHEAT	11638.64 (57)	145.80 (5)	1.20	3.01
OIL SEED RAPE	2068.96 (33)	122.10 (3)	5.90	2.52
CAULIFLOWER	107.52 (4)	107.52 (4)	100.00	2.27
SPROUTS	156.37 (5)	100.70 (3)	64.39	2.08
BROCCOLI	91.22 (3)	91.22 (3)	100.00	1.88
VINING BEANS	221.94 (6)	81.00 (1)	36.49	1.67
CHINESE LEAVES	72.82 (2)	72.82 (2)	100.00	1.50
WINTER BARLEY	2686.38 (37)	49.50 (3)	1.80	1.02
LINSEED	972.69 (19)	27.85 (2)	2.80	0.57
LEEK	23.08 (3)	23.08 (3)	100.00	0.48
BLACKCURRENT	17.34 (3)	17.34 (3)	100.00	0.36
SPRING WHEAT	1140.20 (17)	16.20 (1)	1.40	0.33
RADDICO	16.20 (1)	16.20 (1)	100.00	0.33
MUSTARD	15.79 (1)	15.79 (1)	100.00	0.32
STRAWBERRY	12.01 (4)	10.01 (3)	83.00	0.21
DRIED PEA	194.87 (7)	8.50 (1)	4.36	0.18
CABBAGE	47.22 (4)	8.30 (2)	17.57	0.17
RASPBERRY	6.22 (5)	5.76 (3)	92.50	0.12
VINING PEA	931.68 (14)	4.50 (2)	0.48	0.09
FENNEL	4.05 (1)	4.05 (1)	100.00	0.08
CELERAC	4.05 (1)	4.05 (1)	100.00	0.08
GOOSEBERRY	3.24 (2)	3.24 (2)	100.000	0.07
SPRING BARLEY	1586.93 (16)	0.00	0	0.00
FORAGE MAIZE	87.43 (4)	0.00	0	0.00
OATS	60.35 (3)	0.00	0	0.00
OTHER BEANS	536.74 (19)	0.00	0	0.00
SPRING ONION	14.70 (1)	0.00	0	0.00
TOTAL	29268.81	4827.65	16.49	100.00

(chinese leaves, raddico for example) and high value, frost vulnerable, fruit crops have a very high proportion of the total area of production under irrigation. For all of these products the gross margin method of calculating the value in use of water (see 3.5) tends to under estimate values, since irrigation is employed not simply to increase yields but also to meet product quality requirements.

3.5 Value in Use: Gross Margin Analysis

3.5.1 Method

Gross margin analysis allows estimates to be made of the value of the productivity gains generated by water use and the productivity losses from restricted water availability. The valuation procedure involves several steps:-

(1) Under current irrigation and land allocation practices, estimates are made of the gross margins (total output minus variable input costs) achieved by the farm enterprises.

(2) It is then assumed that no irrigation water is available and that farmers change their crop mix to that which yields the highest net returns under dry farming. This produces a new without irrigation set of gross margin estimates.

(3) By comparing the difference between the gross margins calculated under (1) and (2) above, an estimate can be made of the short run value in use of the irrigation water. Such short run values are important since they will be critical to the farmers' response to any unit water price rises once they have already undertaken investment in water storage and irrigation equipment.

(4) To obtain longer term value in use measures and to estimate the demand for new abstraction authorisations it is necessary to take account of the costs incurred in water storage and irrigation. That is, for irrigation to be financially viable, total

gross margins with irrigation less the discounted annual irrigation costs (capital and operating) must be greater than the margins achieved without irrigation (ie those calculated under step 2).

From the farm survey questionnaire data on current land allocations, irrigated acreage, yields and water application was obtained for the 1989/91 season. However, it was not feasible to obtain the highly detailed information on achieved crop sale prices and the general variable costs associated with the production on individual crops or livestock enterprises. Therefore, gross margin data for the first step in the valuation procedure was obtained from secondary sources. The main source was the University of Cambridge's Farm Business Survey of the Eastern counties of 1990-91 (Cambridge 1992). This is a general farm survey conducted each year by the University on behalf of the Ministry of Agriculture, Fisheries and Food, and represents by far the most reliable source of enterprise gross margins for the Anglian region. Where gross margins for particular crops/livestock enterprises were not available from the Cambridge survey, estimates were made using data from Nix (1991) with adjustments for regional variations.

Use of the Cambridge survey as the prime information source necessitated the disaggregation of the surveyed sample farms into three groups based on farm size and soil type, for which published gross margins were available for the range of crop and livestock enterprises. The three categories were:

- upland farms over 400 hectares
- upland farms under 400 hectares
- fenland farms

Table 3.12 gives the breakdown of the sampled farms into these three categories: one farm in the survey employs the abstracted water solely for domestic purposes, despite having an agricultural licence, and so was omitted from the analysis. The use of the Cambridge survey prohibited a greater degree of disaggregation, as the sample size of each category was small and would have introduce a potentially important source of statistical error into our analysis. Ideally, disaggregation of fenland farms by size and greater disaggregation of all farms by soil types would have been desirable; however this proved impracticable.

FEN FARMS	WITH STORAGE	9	11.2%
	NO STORAGE	8	12.6%
OVER 400 UPLAND	WITH STORAGE	11	15.4%
	NO STORAGE	6	8.4S
UNDER 400 UPLAND	WITH STORAGE	26	37%
	NO STORAGE	11	15%
		71	100%

Table 3.12 Breakdown of Sample into Farm Size, Soil Type and Presence of Storage.

Information for step 2 of the valuation procedure was obtained from the farm survey questionnaire (Appendix 1, Q9). As expected farmers varied somewhat in their preferred cropping options when irrigation water was unavailable and dry farming had to be adopted. However, re-allocation of the previously irrigated land to winter wheat production was the most common response and the most financially sound option for most farm businesses. To simplify the calculations it was, therefore, assumed that all farm businesses would adopt the winter wheat option.

3.5.2 The Results: Short-Run Value in Use

As expected, when comparing the gross margins achieved under current irrigation crop regimes and the non-irrigated winter wheat option, the later are significantly lower. In aggregate for each of the three farm type groups, as table 3.13 part A illustrates, fen farmers would face a 10% decline in gross margins, while the over and under 400 hectare upland concerns would see their margins decline by 27% and almost 39% respectively. When these reductions are applied per irrigated hectare, per authorised abstraction quantity and per actual units of water applied, the greatest losses are experienced by fen farms, although major losses would occur for all groups.

PART A:	FEN	OVER 400 UPLAND	UNDER 400 UPLAND
IRRIGATED GROSS MARGIN (£)	577528096.5	166160137.2	106691822.36
WHEAT GROSS MARGIN (£)	519700446.46	121028836.4	65259867.8
DIFFERENCE	58827650.10	45131300.7	41431954.5
% CHANGE	10.18%	27.16%	38.8%
PART B: LOSS AGGREGATE			
ZERO*	6	5	19
UNDER £50,000	0	0	0
£50,000-£500,000	0	1	11
£500,000-£1 MIL	1	3	1
£1 MIL -£5 MIL	7	4	4
OVER £5 MIL	3	4	2
PART C: LOSS PER IRRIGATED HA			
ZERO*	7	4	20
UNDER £1,000	0	0	0
£1,000-£5,000	0	3	3
£5,000-£15,000	0	5	4
£15,000-£30,000	3	2	3
£30,000-£50,000	3	3	3
£50,000-£100,000	3	0	2
£100,000-£500,000	1	0	2
OVER £500,000	0	0	0
PART D: LOSS PER AUTHORISED MEGALITRE			
ZERO*	8	7	21
UNDER £500	0	0	0
£500-£1000	0	0	2
£1000-£5000	0	0	3
£5000-£10,000	1	4	2
£10,000-£50,000	2	4	5
£50,000-£100,000	3	0	2
£100,000-£500,000	3	2	1
OVER £500,000	0	0	1
PART E: LOSS PER ACTUAL MEGALITRE EMPLOYED			
ZERO*	1	1	6
UNDER £500	0	0	0
£500-£1000	0	0	1
£1,000-£5,000	0	0	1
£5,000-£10,000	0	1	4
£10,000-£25,000	0	1	2
£25,000-£50,000	0	4	3
£50,000-£100,000	3	2	3
£100,000-£500,000	3	0	1
OVER £500,000	1	1	0

Table 3.13 Short Run Margin Losses.

*Some of these are missing values.

It should be noted that the last figure (actual water applied) is subject to (possibly considerable) error since it depends on the farmers' estimation of their consumption. However, the figures do provide some broad guidance as to the general value in use of water under short-run conditions.
There is a real possibility that the derived values actually underestimate the true values for dry years. This arises since a number of the surveyed farms were either physically unable to abstract the quantity of water they required for maximum crop yields or were affected by the abstraction bans imposed by the NRA early in the growing season. Therefore the yields obtained and importantly crop quality were reduced in the 'with irrigation' case. This was particularly important for potato growers where susceptibility to potato scab and growth are both highly water dependent. To some, but an unknown, extent this under-estimation problem could counteract the over-estimation of values which inevitably occurs when the value of irrigation is estimated for only dry weather conditions. As explained in 3.3.1, the real value of an authorisation and of the investment in irrigation has to take into account the wet years when the additional yields generated by irrigation will inevitably be much lower.

When the results from this section of the analysis were subject to greater scrutiny by analysing the outcomes for individual farms, marked variations within the three groups was revealed. This was most evident for fen farms and upland farms of under 400 hectares, and may in part reflect problems associated with the gross margin values used from the Cambridge analysis. This is particularly true for the under 400 upland category, which also includes highly intensive market garden style operations on relatively small areas of land. Individual farm loss levels are critically dependent, as one would expect, on the actual crops grown being strongly related to potato quota and horticultural outputs.

As Table 3.12 clearly shows almost half of the surveyed farms would experience very major net revenue losses if they were forced to adopt dry farming. For thirty seven farms the losses (and thus the gross value of irrigation) were over £50,000 for the business as a whole, and in two cases losses of £17 and £18 million would be incurred. Both of these farms grow very high value vegetable crops on sandy soils, and non irrigated wheat (or oil seed rape) would achieve very low yields on such soils. When the results from the businesses likely to suffer losses of over £50,000 were analysed to assess the losses (ie irrigation value) per hectare and per megalitre of water, high water values, greatly in excess of current authorised prices, were encountered. However, it was found that for 27% of the sample (19 cases) zero or negative margins were established. Interestingly 14 of these cases were summer only licence holders, which strongly suggests that poor supply reliability over the season has had a major impact on margins. The negative margins experienced by the remaining 5 farms, who held winter licences, was anticipted since thay irrigate grassland for dairy-beef enterprises. As explained earlier the gross margin approach underestimates the value of irrigation for this group of farms since it ignores feed cost savings.

The figures do however, suggest that for enterprises without storage the current irrigation regime is uneconomic even before the costs of the irrigation equipment (and the licence) have been taken into account. The interviews suggested that there were two explanations for these apparently non-economic practices: first the restricted natural water availability and the abstraction bans (discussed above), and, second normal rotational changes to limit exposure to the risk of eel worm infestations of the potato crop. However, even taking account of these factors, there seems little doubt that irrigation is, at best, of marginal viability for some farmers. Their net revenue from irrigation is already less than the prices paid for their abstraction authorisations. While it could be assumed that further, relatively minor, water price rises would encourage such farmers to leave irrigated agriculture, this is not necessarily the case. The fact that the licence in itself has value, since it acts to enhance land values (see 3.8) deters farmers from relinquishing all or part of their licence. Moreover, it was clear from the questionnaire survey that farmers do see irrigation as a form of insurance policy, as a method of keeping crop mix options open to combat uncertainties in market conditions.

3.5.3 The Results: Long-Term Value in Use.

The fourth step in the gross margin analysis is to assess the value in use of irrigation water in the longer term taking into account the annualised costs of irrigation equipment and water storage. Details of the method employed to calculate these costs from the results of the farm questionnaire survey are given in 3.6. It must be noted that not all farmers were able to give enough cost information to provide a useful input into this part of the analysis; the effective sample has, therefore, been reduced to 49 for the irrigation equipment costs and 31 for storage costs. Long-term gross margins from irrigation were calculated by deducting annualised equipment costs and annualised storage costs (where applicable) from the gross margins calculated under step 1 of the valuation procedure. The new figures were then compared with the net returns from winter wheat production on the previously irrigated acreage (step 2).

Calculations were made using total equipment and storage costs, and separately for farmers with and without storage. Losses or net returns due to the removal ofthe irrigation option were estimated per irrigated hectare and per megalitre of authorised abstraction. Table 3.14 presents the salient results, under one set of assumptions about the cost of capital. As explained in 3.6, the results were tested for their sensitivity to changes in interest rates, different price index deflators and for different levels of grant aid towards equipment and storage facilities. The results were insensitive to such changes which means that it is unnecessary to present the full range of cost of capital scenarios here.

PART A	FEN	OVER 400 UPLAND	UNDER 400 UPLAND
IRRIGATED GROSS MARGIN-ANNUALISED CAPITAL COST-WHEAT GROSS MARGIN (£)	48520630.7	44929094.3	39110268.2
% CHANGE	8.4%	27%	36%
PART B: LOSS AGGREGATE (£)			
ZERO*	2	5	9
UNDER £50,000	0	0	2
£50,000- £100,000	0	0	0
£100,000-£500,000	0	1	6
£500,000-£1 MIL	1	3	2
£1 MIL-£5 MIL	6	4	4
OVER £5 MIL	2	0	0
PART C: LOSS PER AUTHORISED MEGALITRE			
ZERO*	3	6	8
UNDER £500	0	0	0
£500-£1,000	0	0	1
£1,000-£5,000	0	0	3
£5,000-£15,000	0	3	3
£15,000-£30,000	1	2	0
£30,000-£50,000	1	1	4
£50,000-£100,000	3	0	2
£100,000-£500,000	4	2	1
OVER £500,000	0	0	
PART D: LOSS PER IRRIGATED HA			
ZERO*	2	3	6
UNDER £500	0	0	0
£500-£1,000	0	0	1
£1,000-£5,000	0	1	2
£5,000-15,000	0	5	4
£15,000-£30,000	3	3	3
£30,000-£50,000	3	2	3
£50,000-£100,000	3	0	2
£100,000-£500,000	1	0	1
OVER £500,000	0	0	1

Table 3.14 Long Run Margin Losses

* Some of the values are missing values.

As expected the apparent losses from the removal of the irrigation option are significantly less than those recorded in Section 3.5.2. When both equipment and storage costs are included 33% of the surveyed enterprises recorded zero or negative loss values; in other words irrigation was uneconomic and the farmers would increase their net returns by moving into dry farming. Once again the evidence suggests that non-viability is closely associated with lack of storage.

A number of explanations for this apparent financial irrationality have already been discussed in the context of the short-run value in use estimates. It was abundantly clear that the NRA's imposition of an abstraction ban at a crucial stage in the cropping season produced a marked decline in yields, and perhaps more importantly a reduction in crop quality. The paradox is that under the gross margin valuation procedure the ban has acted to reduce estimated returns from irrigation and thus the apparent value of water, whereas given the dry weather conditions the marginal value of unrestricted irrigation would have been high. Farmers who produce under specific contracts with supermarkets, potato crisp manufacturers and wholesalers are particularly affected by water shortages which lead to failure to meet the buyers' stringent quality criteria. It is perhaps worth noting here that potato crisp manufacturers are now switching to new breeds of potato, which are more water sensitive, and there is evidence beginning to emerge that these companies are stipulating irrigation as a criterion for contract renewal. Given the importance of potatoes in irrigation agriculture within the East Anglian region, this feature could be important since it effectively acts to add value to an abstraction licence.

Another reason for the retention of notionally irrational agricultural practices arises in the already discussed case of dairy units employing irrigation on grass land. As the additional yields from grass land irrigation are relatively low in value terms, the gross margin method of valuation reveals non-viability. But the method fails to take account of the high additional costs incurred by farmers in purchase of concentrated feedstuffs if home produced hay and silage was not available. In the case of two farmers with unviable investment in water storage, it was found that the storage was not purely used for irrigation but for amenity/wildlife reasons.

Moving to the group of farmers for which irrigation is financially viable, it is clear that the rate of return on investment in irrigation is high, and thus values in use of water are also high. Thirty one of the farms recorded values of over £50,000 per megalitre; most of these irrigate relatively small acreages of very high value fruit and vegetables. Clearly this group would be unresponsive to even major unit water price rises.

3.5.4 Sensitivity of Results to Gross Margin Variations

PERCENTAGE	ALL FARMS	FEN	OVER 400 UPLAND	UNDER 400 UPLAND
UNDER 5%	15	6	3	7
5%-10%	11	5	4	1
10%-20%	4	0	2	2
205-30%	1	0	0	1
	31	11	9	11

Table 3.15 Impact of Change in Potato Gross Margin.

The results can be re-evaluated to examine their sensitivity to the values adopted as gross margins. In the light of recent political decisions to reduce agricultural prices (MacSharry proposals, Gatt Round), the gross margin analysis has been reevaluated under the assumption that the potato gross margin declines by 15%. Potatoes were chosen for the exercise because of their importance in the region. Assuming that the area allocated to potato production remains unchanged (which is unlikely to happen in practice), the impact that such a change has on the profitability of irrigation on individual farm businesses is shown in table 3.15. Assuming that there is no alteration in land allocations, the farm businesses experience a decline in total farm gross margins which range from a fall of only 0.02% on one upland farm of under 400 ha to a fall of 14% also on an upland farm of under 400 ha. In the latter case, the impact of the reduction in the gross margin was large as 146 ha had been allocted to irrigated potatoes. The average percentage change for the 31 farms analysed was 6.6%.

3.6 Expenditure on Water Storage and Irrigation Equipment

3.6.1 Introduction

Estimates of the annual cost to farm businesses of the water storage facilities and irrigation delivery systems are not only vital as an input into the gross margin analysis but also could in their own right yield useful information on water value in use and on the willingness of farmers to pay for increased supply security. In the first place, the cost of storage facilities installed to allow winter abstraction indirectly provides an estimate of the minimum value to the farmer of having a summer licence. In other words, storage expenditure is an alternative to direct water abstraction at the needed time of use. Second, storage in some cases has been installed to improve supply reliability and its cost, therefore, gives a crude minimum value of increased supply security. And thirdly, the total cost to the farm business of the storage and irrigation equipment provides a very basic estimate of the minimum value of irrigation water (and the licence) since this is the actual cost they willingly incure in addition to the price paid for the water itself.

3.6.2 Estimation Method

Since all of the data for these cost estimates were obtained from the farm survey (Q's 2 and 10), the results will therefore, depend on the accuracy of the farmers' responses. Only 31 with storage and 49 with irrigation equipment cases were employed in the analysis; all but three of the rest of the surveyed farms were unable to give any reliable cost details. Three farms able to give storage cost information were also excluded since their capacity was developed in conjunction with sand and gravel extraction companies. In return for the commercial rights to the sand and gravel, the extraction companies agreed to ensure that the excavated pit was suitable for on-farm water storage. From the farmers' viewpoint the storage was a free good and inclusion of these cases would have biased downwards the storage cost estimates.

To undertake the cost analysis a number of simplifying assumptions were necessary. First, since investment in irrigation equipment and storage took place at different periods of time, it was necessary to convert the expenditures to a single (and thus comparable) time value. In effect, the investment was treated as though it took place in 1990, immediately prior to the harvest season during which the farm survey took place. All the irrigation investment costs were converted to 1990 values using appropriate price indices. Two alternative indices were selected, the national retail price index (RPI) as published in "Economic Trends' (CSO Annual) and an agricultural price index (API) published annually by MAFF.

Second, a set of assumptions associated with the notion that capital goods represent stock variables whereas the services they render, the main concern of the farm business, are flow variables. Therefore, it is necessary to convert the stock valuations into a stream of annual expenditures. The cost of irrigation equipment investment comprises two elements: depreciation and the opportunity cost of funds employed.

Using standard farm management procedures, depreciation was calculated on a linear basis and related to years of expected life of the relevant facility: reservoirs were assumed to have a life of 30 years with an annual depreciation rate of 1/30 implied; other source works, pumps and power units, portable field applicators and miscellaneous equipment were assumed to have a life of 15 years with an implied depreciation rate of 1/15 per annum. The opportunity cost of capital was calculated at three different interest rates to reflect the financial uncertainty surrounding the national economy in 1990. The interest rates selected were 2%, 5% and 8%. The 5% rate was seen to be the one most in line with current public sector guidelines. The 2% and 8% rates were used to test the robustness of the results to changes in interest rate. Investments made prior to 1960 are assumed to have been fully depreciated and have a zero opportunity cost of funds employed. Since grant aid was available during the years 1960 to 1985, but not at the time of the survey, from a farmer's perspective this reduced the effective cost of investment capital; the aid does not, of course, reduce the cost to the economy as a whole. To test the sensitivity of the cost estimates to grants, aid rates of 0%, 15%, 25% and 50%, all of which were available at particular times during the study period, were incorporated into the analysis. Nix (Annual) provides full details of the nature and levels of these fiscal incentives and their changes over time.

The opportunity costs of all funds employed and the physical depreciation on the actual facilities are associated with the initial outlay and maintenance of the capital stock. It is also necessary to consider recurrent or operating expenditures. In the case of storage facilities, operating costs are assumed to be negligible and a zero cost imputed. While operating costs for irrigation equipment are unlikely to be negligible, the estimates presented here exclude these costs since attempts to elicit this information directly from the surveyed farmers proved problematic. However, secondary sources such as that published in Hinton and Varvarigos (1990) provide some, albeit limited, cost evidence which was employed to test whether the presented results were sensitive to the neglect of irrigation recurrent costs; they did not prove to be so.

3.6.3 Storage and Equipment Costs.

Capital cost estimates can be expressed in a number of ways: in absolute terms, per unit of storage capacity, per megalitre of authorised abstraction, per megalitre of actual abstraction and per hectare of irrigated land.

Turning first to the absolute annual storage costs incurred by the surveyed enterprises. Although Table 3.16 shows there to be a major variation between farm businesses in general the storage costs proved to be relatively low. Even excluding those firms where storage capacity was a free good, a by-product of sand and gravel extraction, a significant number of businesses incurred minimal

	2%	2%	5%	5%	8%	8%
	R.P.I.	A.P.I.	R.P.I.	A.P.I.	R.P.I.	A.P.I.
UNDER £500	9	11	7	9	6	6
£500-£1,000	7	8	4	2	4	5
£1,000-£5,000	11	9	13	12	14	17
£5,000-£10,000	3	2	4	7	2	1
£10,000-£50,000	1	1	3	1	3	2
OVER £50,000	0	0	0	0	0	0
	31	31	31	31	31	31
AVERAGE (£)	2133	2105	3333	3105	4134	3851

Table 3.16 Estimates of the Annualised Cost of Investment in Storage.

annualised investment costs of less than £1000 per annum; this was even the case when an 8% opportunity cost of capital was assumed. Remarkably few businesses incurred annualised costs in excess of £10,000 even at the highest opportunity costs of capital. It is worth noting at this point that the gross margin analysis (both short and long-run) revealed that a substantial number of businesses were achieving irrigated margins over the dry farmed wheat option in excess of £50,000 per annum. This would suggest that there are opportunities available for the NRA to increase the winter only licences, which would force irrigators into storage options, without materially affecting the value in use derived from irrigation. Given that summer only abstractors were more likely to have uneconomic irrigation, the move to storage and winter only licence need not have a material effect on farm returns. The capital cost estimates proved to be relatively insensitive to the price indices employed, but were sensitive to the chosen real opportunity cost of capital.

PART A:	AGGREGATE	PER AUTHORISED MEGALITRE	PER ACTUAL MEGALITRE EMPLOYED	PER IRRIGATED HA	PER MEGALITRE STORAGE CAPACITY
SUM	10339.52	1071.24	3779.0	1381.11	3758.90
COUNT	31	31	31	31	31
MEAN	£3333.53	£34.55	£121.90	£44.55	£121.25

PART B:	
UNDER £5	1
£5-£10	5
£10-£20	5
£20-£30	9
£30-£40	1
£40-£50	2
£50-£100	7
OVER £100	1

Table 3.17 Cost of Storage, Using a 5% R.P.I Capital Scenario.

Although once again the cost estimates per megalitre authorized reveal a wide range of values, in the majority of cases the values are relatively low in relation to the margins generated by irrigation, as is the average cost of £34.55 per megalitre(see table 3.17). This suggests that for many enterprises the value of holding summer licences is not great and that the NRA has the potential of influencing irrigators to develop additional storage capacity by adopting pricing policies which reflect the full marginal costs of summer peak abstraction. At present for 35% of farms the storage costs are already below the authorised summer abstraction charge. However, not withstanding the generally low annual storage cost figures there is 1 firm (under the 5% cost of capital assumption) and 7 (under the 8% assumption) where the storage costs alone exceed the price per megalitre for metered water supplies taken from the water companies, before the price of the authorised quantities is considered. Although, as will be discussed in 3.7, most farmers rejected metered supplies as a viable irrigation option the data would indicate that this rejection is not necessarily valid for all enterprises. Faced with the apparent increasingly uncertain nature of summer and all year abstraction licences, and high nongrant aided storage costs, it is conceivable that some businesses producing high gross margin crops will come to view metered water as a viable option. This clearly would have implications for NRA policy.

PART A:	2%	2%	5%	5%	8%	8%
	R.P.I.	A.P.I.	R.P.I.	A.P.I.	R.P.I.	A.P.I.
UNDER £500	8	7	6	6	3	4
£500-£1,000	7	8	4	4	3	3
£1,000-£5,000	25	24	24	24	19	19
£5,000-£10,000	4	5	4	6	10	10
£10,000-£50,000	5	5	11	9	13	12
OVER £50,000	0	0	0	0	1	1
	49	49	49	49	49	49

PART B:	AGGREGATE(£)	COST PER AUTHORISED MEGALITRE (£)	COST PER IRRIGATED HA (£)	COST PER MEGALITRE OF STORAGE
SUM	374019.41	7186.55	5286.63	18549.30
COUNT	49	49	49	31
MEAN	7633.04	146.66	107.87	598.36

PART C:	
UNDER £10	1
£10-£20	2
£20-£30	5
£30-£40	5
£40-£50	5
£50-£100	14
£100-£200	10
£200-£300	1
£300-£400	2
£400-£500	1
OVER £500	3
	49

Table 3.18 Estimates of the Annualised Cost of Investment in Water Storage and Irrigation Equipment. (under 5%R.P.I. Capital Scenario).

When the annualised costs of irrigation equipment are combined with those for storage, as given in absolute terms in Table 3.18, the range of the values is greater than before but the same general points hold. That is, the sample reveals a wide dispersion of annual costs and these would appear not to be highly sensitive to the choice of price indices, but would appear to be sensitive to the choice of interest rate. The total cost of storage and irrigation equipment ranged from £12 to £1421 per megalitre per year, while the average was £147 per megalitre per year. These figures give a highly crude indication of the value of the irrigation water since they have actually been incured. However, at the highest per megalitre levels is is difficult to interpret this in economic rationality terms.

3.7 Maximum Value in Use as Estimated by Metered Water Costs

3.7.1 Introduction

Storage expenditure represents one surrogate measure for the value of direct water abstraction at the needed time of use; note that it should represent the minimum value in use. Metered water costs on the other hand could be regarded as the maximum value of direct abstraction. The farm survey questionnaire, therefore, attempted to establish mains water usage practised, the extent to which mains supplies were employed to supplement abstraction, and the price at which mains water would become viable as an irrigation supply.

3.7.2 Results

None of the surveyed farm businesses employed mains water for irrigation; indeed only 28 reported using it at all, usually in small quantities (under 20 megalitres) for general farm purposes, such as washing down, and for livestock. Even under drought conditions, no farmer claimed to have employed mains supplies to supplement abstraction or to circumvent the NRA abstraction ban. Moreover, over 65% of the sample argued that mains water was not a viable alternative for irrigation purposes, since the use would necessitate major adjustments to on farm water distribution systems and the land allocated to irrigated crops. In these cases, the price per megalitre of supply was viewed as somewhat irrelevant . When asked what reduction in mains water price was required to make it a viable option only two farmers were prepared to consider taking supplies if the price was reduced by 50% and 70% respectively. Two others indicated that storage would be considered first, and the rest claimed it

		FEN	OVER 400 UPLAND	UNDER 400 UPLAND
HIGH WATER £470	GROSS MARGIN MINUS IRRIGATION EQUIPMENT PLUS HIGH WATER COST	513348651.5	163062399.3	94974566.0
	WHEAT GROSS MARGIN	468025472.3	118820798.5	56408875.0
	DIFFERENCE	45323179.2	44241590.8	38515691.0
	% CHANGE	8.8%	2.7%	4.05%
MEDIUM WATER COST £400				
	GROSS MARGIN WITH IRRIGATION MINUS EQUIPMENT COST PLUS MEDIUM WATER COST	513349491.5	163063377.3	94975966.4
	WHEAT GROSS MARGIN	468025472.3	118820798.5	56408875.0
	DIFFERENCE	45324019.2	44242578.8	38567091.4
	% CHANGE	8.8%	2.7%	4.06%
LOW WATER COST £350				
	GROSS MARGIN WITH IRRIGATION MINUS EQUIPMENT COST PLUS LOW WATER COST	513350091.54	163664077.0	94976966.4
	WHEAT GROSS MARGIN	468025472.3	118820798.5	56408875.0
	DIFFERENCE	45324619.2	44843279.5	38568091.4
	% CHANGE	8.8%	2.7%	4.06%

Table 3.19 Maximum Loss Values Incorporating Mains Water Costs.

would never be viable or simply could not answer the question.This widespread rejection of the mains water alternative was somewhat surprising. As indicated in the previous section there are already cases where the storage costs incurred per megalitre of supply exceed water company prices. It is evident that in the short-run farmers who have already installed storage facilities and with existing licences normally sufficient to meet their needs, will not view mains as a viable supply supplement since, the location of their irrigated acreage is essentially fixed by their storage and abstraction points. However, in the longer term the case is unlikely to be so clear cut. In the first place, except in those relatively unusual situations where soil types vary markedly across the farm business, adjustments to the location of the water input points are feasible. If an established abstractor cannot obtain additional licences to extend the irrigated area, or the abstraction point becomes unacceptably unreliable, then a new irrigation area based on mains supply could be financially viable. This can be seen from Table 3.19, where the mains water price (lowest, average and highest) has been added to the annualised equipment costs. The new cost figure is then subtracted from the gross margins achieved by irrigation (short-run case) and the results compared with the gross margins under the dry farming winter what option. Irrigation is still on average viable although as would be anticipated a considerable range of figures were obtained when the sample was disaggregated into individual farms.

Secondly, the survey obviously only covered those farm enterprises with established licences; no data was available from which to assess the response of those with rejected licence applications or those who had not bothered to apply for a licence assuming rejection. In view of the very high marginal values in the use of water established for some producers, even taking the annualised equipment costs into account, there are distinct possibilities that producers of high value crops would employ mains supplies. Clearly, this potential has implications for NRA policy since the overall water resource situation would not be improved if rejection of an irrigation licence simply led to the increased sale of expensive treated water for irrigation purposes. More work is necessary to establish the facts of the case either by studying the practices of water company agricultural customers, or, if company co-operation could not be obtained, by selecting a sample of areas where high value crop production was known to be concentrated.

3.8 Value in Use as Measured by Land Value Differentials

3.8.1 Introduction

As discussed in 3.2, there are a number of overseas studies which attempt to employ land sale and rental prices to give estimates of the value attached to water abstraction rights. No known research has been conducted in the United Kingdom which adopts this valuation technique. This is perhaps surprising since as early as the late 1960s there was some evidence that the 'first come, first served' method of allocating water rights was giving scarcity value to the licences and enhancing the holders' land and property values (Rees 1970). As a result abstractors were unwilling to release licensed quantities in case they needed to realise land or property assets. Given the NRA's increasingly stringent approach to the issue of new abstraction licences, particularly in water short East Anglia, there were grounds for thinking that the land value effect could be significant. It was also possible that long established 'licences of right' with their greater security of tenure, would generate the highest value; this would be somewhat analogous to the situation in the western United States where senior (first priority) water rights have the greater tradeable values.

Study of with and without licence land values was thought to be important for three reasons. First, it could provide a useful measure of the value of the licences themselves, and thus of abstracted water. Conceptually, the productivity gains from the water should be capitalised into the sale or rental value of the land to which the licence is attached. Second, if there is a significant land value effect, then it is likely that abstractors will be unresponsive to any attempts by the NRA to re-allocate authorisations through increases in the per unit price for authorised abstraction quantities. Third, the study should provide some indications of the potential to develop a marketable permit system where the value of the licence becomes a tradeable asset separate from the land it previously irrigated.

3.8.2 Method

While the present study makes no claims to be an in-depth investigation of the land value enhancement effect, it does provide some insights into the issue. Ideally, with and without licence land value differentials should have been assessed through analysis of actual land sale or rental records. This would have been a major analytical exercise beyond the scope of the current research project. Instead three alternative methods were employed to provide some crude evidence on land value differentials. First, as part of the farm survey (Question 11) managers were asked to recount their experience of the impact of abstraction rights on land prices and rents and also to respond to the hypothetical question of how willing they would be to pay a premium for land with an established authorisation. As with all such contingent valuation exercises, the accuracy of the results critically depends on whether farmers respond to the hypothetical situation in the same way they would react if faced with the decision in practice. Second, a telephone survey was conducted of a sample of farmers holding agricultural licences, which had been unutilized over the previous 5-10 years. NRA Anglian region records provided details of 37 farmers falling into this category. It was hypothesized that a major reason why such long-term non-users would retain the licence was because of the land value effect.

The third method involved interviewing the major land agents in the region about their recent experience of the impact of abstraction rights on land sale prices or rents achieved. In all, 12 agents were contacted. All claimed that a licence would add value to an agricultural property, with the size of the premium depending on type of licence, volume authorised, season of abstraction, soil type and the reliability of the supply. However, only one company, Bidwell PLC, was prepared to provide actual valuation details free of charge, the remainder required payment for the information. The results given in Section 3.8.4 are, therefore, based only on the Bidwell data.

3.8.3 The Results: Farm Survey

Farm managers were asked to consider their experiences of the impact of the abstraction licences on land and rental values. 63% reported that an abstraction licence did have an impact on land values. For those renting land, mainly for specific potato contracts the price varied from £60-£80 per acre for land with no abstraction licence to £180-£200 per acre for land with a licence. In cases where the potato quota was included in the land plus water deal, a figure of £380 per acre was given. The majority of those farmers who claimed an abstraction licence added value, also claimed that a water abstraction licence was a critical factor in the decision to purchase land, with 25% claiming that they wouldn't buy land without a licence. The ability to irrigate according to the surveyed farmers added value in the range of £50-£400 per acre to land sale prices, with one farmer having paid a premium of 50% for sandy land with an abstraction licence.

% PREMIUM	ALL FARMS	FEN	UNDER 400 UPLAND	OVER 400 UPLAND
10%	2	1	1	0
20%	5	3	2	0
30%	2	0	0	2
40%	3	0	1	2
50%	9	5	0	4
60%	0	0	0	0
70%	1	1	0	0
	22	10	4	8

Table 3.20 Premium Farmers Willing to Pay for Land with an Abstraction Licence.

Turning to the more hypothetical question about willingness to pay a premium for land with an abstraction licence, 31% of the sampled farms were willing to pay premiums. As Table 3.20 shows these premiums proved to be unexpectedly high. Over half the farmers expressed a willingness to pay in excess of 40% or more for 'with licence' land and one farmer would go as high as 70%. With average 1991 land prices per hectare being approximately £4,500, the implication is that licences can have a value of upto £3,000 per irrigated hectare.

As expected the willingness to pay premiums does vary with soil type and the crop mix of the farm business. There was some evidence, albeit from an obviously very small sample, that farmers on the fenlands were more likely to pay premiums; 59% of all fen farmers would pay a premium compared with 22% of upland farmers. (Table 3.20). One potentially important finding was that the availability of potato or sugar beet quotas appeared to be a critical factor for those managers expressing a willingness to pay high premiums.

Attempts were made to explore the farm characteristics associated with willingness to pay different levels of premium, and also to establish whether there were any significant differences between those farms unwilling to countenance any premium and those prepared to do so. It was hypothesized that three factors relating to the licences themselves could have an influence. First, that concerns with small licences in relation to the size of the land holding would be more prepared to pay premiums. Second, that farmers with renewable licences would pay extra for land with a licence of right and, third, that those with winter only licences would find premiums acceptable in order to obtain summer or all year authorisations. However, with our sample the latter hypothesis was untestable since virtually all winter only licence holders already held summer licences. Although there was some indication that small licence holders were more prepared to accept premiums the only significant factor explaining cross farm variations was the dominant crop produced on the already irrigated acreage. It was conceptually possible that farmers producing high gross margin crops, and particularly those with supply contracts containing strict product quality specifications, would be more willing to pay land premium. This proved to be the case.

3.8.4 Bidwell Data

Some verification of the potentially high land value increments generated by an abstraction licence was provided by data from Bidwells, one of the largest land agents nationally. It was suggested that a licence of right would add 30% to the value of grade 1 or 2 agricultural land, while a lower premium of 10-15% would occur for a renewable licence. Where a winter abstraction licence and adequate reservoir storage was part of the sale, the premium could be 50%, reflecting both the lower cost of the water itself and the higher security generated by storage. Availability of storage was particularly important under current dry weather conditions where farmers relying on run of river abstraction were unable to obtain their authorised quantities and were subject to NRA abstraction restrictions. Bidwells suggested that the greatest premiums would occur for agricultural land with sandy soils; such land without a licence would at 1991 values secure approximately £1715.7/ha(£700 per acre) , but this could increase to£3308.8/ha (£1350 per acre) where a licence was available; this represents a 95% premium. Table 3.21 sets out what this range of premiums means in terms of average land values in the region; it indicates that licences appear to have marketable values per irrigated hectare of between £550 and £4,500. It must be noted, however, that there is now some evidence that the NRA notices of licence suspension (the red notice) are having a negative impact on land values and thus on the 'with licence' premiums (see Big Farm Weekly, 3.3.92).

	AVERAGE PRICE PER HA	10-15%	30%	50%	95%
GRADE 1+2	£4,502	£675.30	£1,350	£2,251	£4,276.9
GRADE 3	£4,996	£749	£1,498	£2,498	£4,746.0
GRADE 4+5	£3,730	£559.50	£1,119	£1,865	£3,543.0
ALL GRADES	£4,683	£702.4	£1,404	£2,341	£4,448.8

Table 3.21 Average Land Values 1990-91 Incorporating % Premium..

3.8.5 Non-User Survey

No useful information on land value premiums was obtained from the non-user survey. Of the 37 farms in the original sample population, 13 refused to be interviewed or were unobtainable. While all the rest argued that the abstraction licence added value to their property and this was the dominant reason for its retention, none were willing to indicate what this value was either in absolute or percentage premium terms. All those questioned considered that soil type was the most important factor determining the value generated by the licence.

One interesting result, however, from the non-user survey was that 17 out of the 24 farmers questioned gave unprompted, a second vital reason for retaining the licence - namely as an insurance policy against economic and climatic uncertainty. In view of the drought conditions it was not surprising that climatic uncertainty and the possibility of long-term climatic change came most readily to mind. The annual licence fees were seen to be a relatively minimal insurance premium, particularly as most farmers expected licence values to increase as they became an ever more scarce commodity.

3.9 Risk and Reliability

3.9.1 Introduction

A search of the literature on agricultural water use revealed nothing which explicitly addressed the value in use and willingness of abstractors to pay for different levels of supply security. Some evidence does exist on the losses sustained by farmers during the current drought in eastern England but much is anecdotal. In order to provide some insights into the value of supply security to irrigators, the farm survey attempted to:-

(a) investigate the risk avoidance expenditures actually made by abstractors in catchments where unreliability of supplies was a known problem.

(b) assess, using contingent valuation, the potential changes to cropping patterns and yields which would occur if abstractors either had a 100% reliable supply upto their authorised abstraction quantity or if more abstraction water was available.

(c) estimate, again using contingent valuation, the willingness of abstractors to pay a premium above current licence charges for different levels of supply security. Following discussions with the NRA, three different reliabilities were used - supply sufficient in 4 out of 5 years, 9 out of 10 years and 19 out of 20 years.

(d) examine whether abstractors, in view of the current drought conditions, were planning to adjust cropping practices, install additional storage facilities, or invest in more water efficient irrigation techniques.

3.9.2 Risk Reduction Expenditures and Costs

Conceptually, there is a whole range of strategies which could be adopted by farmers to cope with problems of abstraction supply reliability: use of mains water as a supplement, recycling (livestock enterprises only), development of additional storage capacity and/or the use of more water efficient delivery techniques to enable existing storage to meet irrigation needs, and changes in the crop mix/seed types to less water sensitive varieties. As discussed in 3.7, none of the sampled farm businesses had used mains water as a supplementary supply and none regarded it as a viable potential option. Likewise no cases where recycling had been adopted or was planned emerged from the survey. Predictably, increases in storage capacity was the most common response to past reliability problems and was the preferred future option. However, the inability of farmers already heavily indebted to raise the necessary capital for capacity enhancement was an important limiting factor.

As we have already seen the annualised real cost of storage is low, on average only £34.55 per megalitre per year and for a proportion of the farms this is more than compensated for by the increased productivity of the irrigated area and importantly, by the increased value of improved quality products. The relatively low cost of storage would explain the generally low interest in capital investments in irrigation equipment which was more water efficient. On those occasions when storage capacity was likely to fail to meet optimal irrigation needs, the majority of farmers either simply accepted the productivity losses or instituted the low cost option of initiating night time irrigation.

Apart from storage there was little evidence that farmers had incurred significant expenditure or costs on other strategies to cope with unreliability. Only one case could be found where a farm business had undergone major restructuring as a direct result of the unreliability of supplies. This does not, of course, mean that unreliability has not imposed productivity losses on other concerns (see 3.9.3), but that the farmers appear to be willing to accept the risk rather than adopt less water sensitive cropping regimes; a willingness which can readily be explained by the high returns often achieved by irrigation (see section 3.5).

There were cases where significant expenditure had been made to secure additional supplies and where water shortages had prevented the adoption of the desired, highest margin, crop mix. However, such costs were normally incurred because of the failure of the farm business to secure additional NRA licences for on farm abstraction, rather than as a result of supply unreliability per se. For example, a consortium of farmers negotiated the transfer of supplies from the River Trent to the River Witham, and via the Fen drain system to individual farms. The capital cost of this transfer scheme was £500 per million gallons (at 1991 prices), to which must be added pumping costs, system maintenance expenditure and the price paid to the NRA for the water itself. In another case, major adjustments were made to the crop mix, when the costs of operating the limited irrigation system allowed under the current NRA licence, exceeded the returns on the additional yield. Having failed to obtain an additional licence to get the irrigated acreage up to an economically viable size, the farm has moved out of horticulture and four workers have been made redundant.

3.9.3 Financial Losses From Unreliability

	ADEQUATE DRY YEARS	INADEQUATE DRY YEARS
NEGATIVE	2	2
ZERO	2	5
UNDER £50,000	1	0
£50,000-£500,000	4	5
£500,000-£1 MIL	3	3
£1 MIL-£5 MIL	9	6
OVER £5 MIL	2	7
SUM	45259247.00	88315295
COUNT	23	28
MEAN	1,967793.3	3,154117.7

Table 3.22 Short Run Losses for those Farmers Claiming Abstraction Licence Adequate/Inadequate in Dry Years.

An attempt was made to crudely estimate the real losses incurred during the 1990-91 season by those farmers unable to take their licensed volumes (either due to physical flow limits or to the NRA abstraction ban) or with inadequate storage to cover all their irrigation needs. This was done by disaggregating the total sample into two groups, those who claimed that under dry weather conditions available abstraction water/storage was sufficient to meet their requirements and those with inadequate supplies. The gross margin analysis, discussed in 3.5.2, was then employed to see whether there were any significant differences between these groups. The expectation would be that those affected by supply unreliability would exhibit the lower gross margin loses by moving to the dry winter wheat option.

Calculations were also done to measure the difference in per ha yield achieved with and without irrigation, using data provided by a number of farmers in the sample.. When this yield difference is multiplied by the gross margin per ton of the crop, another crude loss measure is obtained. For potato farmers, for which data from 10 farm enterprises was obtained, the without irrigation return was £37,488 per ha. In the case of sugar beet producers (5 observations) the loss was £24,292 per ha. These measures must be regarded as a minimum figure since output quality is not taken into account, nor are the substantial costs imposed on the farm business when supply contracts are lost.

Not unexpectedly the greatest losses (and thus the highest values for reliability) are encountered in fenland areas, and sandy soil areas, where irrigation is essential for high margin crops. The importance of irrigation reliability to farmers with contracts with supermarkets, crisp manufacturers, and other wholesalers cannot be over-stressed. Once contracts have been lost because of failure to deliver the specified quality products, they can be extremely difficult to re-establish even when farmers install storage to overcome future problems.

3.9.4 Contingent Valuations

When farmers were asked what changes they would make to their cropping patterns if the quantity allowable under the existing authorisation was guaranteed, only a small proportion of the sample (9 in all) would make any changes. Moreover, it was exceptionally difficult to establish, for these nine, whether the crop mix changes were related to improved reliability or to an increase in absolute irrigation supplies; all nine would implement the same changes if the water supply was supplemented. The explanation for this perhaps unexpected lack of response appears to be that farmers have already adopted the cropping patterns and irrigation practices which they see as optimal in years when supplies are adequate, and are prepared to accept the losses that such a strategy implies in restricted availability periods. In fact, the reluctance to adopt less water sensitive cropping options is understandable, given the generally high achieved margins for irrigated agriculture over the dry farming alternative, even for a year when restrictions and drought conditions prevailed.

Another, rather more fruitful contingent valuation exercise was conducted on the willingness of farmers to pay for guaranteed supplies for differing reliabilities. Over 67% of the sample were not prepared to pay any reliability premiums. This figure is broadly consistent with the number of farm businesses who either have licences/storage facilities adequate to meet dry year conditions or are planning the construction of storage capacity. Significantly, 70% of those willing to pay some premium had no storage. Theoretically this group should be very sensitive to price (ie the size of the premium) since for most of them, investment in storage would be a lower cost option in the long term; whether they actually adopt this option is heavily dependent on their capital/debt positions.

		4 YEARS OUT OF 5 YEARS	9 YEARS OUT OF 10 YEARS	19 YEARS OUT OF 20
OVER 400 UPLAND	WITH STORAGE	0	0	1
	NO STORAGE	1	1	1
UNDER 400 UPLAND	WITH STORAGE	1	1	1
	NO STORAGE	2	3	3
FEN	WITH STORAGE	1	1	1
	NO STORAGE	4	4	4
		9 (39%)	10 (43%)	11 (48%)

Table 3.23 Those Willing to Pay for Reliability.

3.9.5 An Apparent Paradox

The results from the work on reliability appear somewhat contradictory. On the one hand, expenditure on storage to combat unreliability is relatively low compared with the margins achieved from irrigation and few farmers are prepared to pay a significant reliability price premium. On the other hand, the financial losses incurred due to supply restrictions can be significant. There appear to be two major explanations for this paradoxical situation. First, as already discussed capital availability constraints are acting to restrict storage construction. Second, it reflects many farmers' attitude towards risk, both climatic and market risks. The real returns from storage are heavily dependent on whether dry years occur soon after the investment is made; farmers expecting or hoping for normal or wet years will delay expenditure. As one farmer put it "developing storage is not worth the risk, as the next year may be wet". There is, however, evidence which suggests these attitudes are changing in the face of four below normal rainfall years and the increasing willingness of the NRA to impose abstraction bans to safeguard river flows and ground water supplies. Market risks, or potential changes in agricultural or pollution control policies, may also be inhibiting investment in greater reliability. For example, any alterations to the potato quota regime could have an important impact in the Anglian region, where the returns from irrigation are heavily dependent on the farmers holding or being able to buy in a quota. Some farmers have already relinquished their quota preferring to take 'opt out' payments.

3.10 Conclusion

A wide range of approaches have been taken to attempt to estimate the value in use of water in agriculture. Evidence contained in the literature has to be scrutinized with care since the evaluation method employed can have a significant effect on the results obtained. However, much of the published evidence has demonstrated that the value in use of water can be extremely high. Our own results from the farm survey support this view.

In the short term, before the fixed costs of irrigation equipment and storage were taken into account, almost half of the sampled firms would experience losses of over £50,000 for the business as a whole if forced out of irrigation into the dry wheat farming alternative. In two cases, the losses would run into millions of pounds, but for such enterprises the use of metered mains water would be a lower cost option than moving into dry farming. Such enterprises would clearly be unresponsive to water price rises. These high values in use, even in the short term, were not, however, by any means universal. Twenty seven percent of the sampled enterprises would achieve as high or higher returns under dry farming before the capital costs of irrigation are taken into account. It would seem that the strongest explanation for the result lies in the unreliability of the abstraction source; the vast majority of unviable irrigators held summer only licences. Although it might be concluded that relatively minor price rises might encourage these farmers to move out of irrigated agriculture and relinquish their licence, this is not necessarily the case. Farmers are concious of the effect of licences on land values and also maintain licences as an insurance policy.

In the longer term, taking into account capital costs, irrigation was a more marginal practice for a higher proportion of enterprises. However, a significant number still achieved rates of return on their investment in excess of the market rates of interest at which the funds had been borrowed. There is no doubt that for an important group of farmers the value in use of abstraction water is considerable. It seems clear that for most the abstracted supply does not have to be made available at time of use. Somewhat unexpectedly the cost of storage was on average relatively low, although the range of costs was high and for a few enterprises it would appear to have been more effective to use mains water than to introduce storage.

The evidence strongly suggests that the NRA has scope to reduce summer only licences without markedly affecting enterprise profitability. There is already evidence that recent drought conditions are encouraging the development of storage; this is most evident in the River Baine catchment where storage is being created in conjunction with sand and gravel extraction companies. The main barrier to increased on farm storage is the level of indebtedness already incurred by farm enterprises.

The value in use of water for some, but of course not all, agricultural enterprises is confirmed by the significant land value premiums which a licence confers. Although the premiums vary with land, preferred crop and licence type, in East Anglia it is clear that on sandy soils a licence of right could add over £3000 per hectare to land values. This land value effect strongly suggests to us that a full cost based charging system might not be effective in producing a reallocation of available abstraction water to the highest value users. Rather a permit trading scheme, which allowed licence holders to realise the value of the licence separate from the land, could be more appropriate. If such a reallocation failed to occur the very high value generated by water would justify supply enhancement expenditure by the NRA, but this would have to be very carefully targetted, taking into account soil type and enterprise mix.

The structure of agriculture in the Anglian region, with the high number of farm businesses with linkages further down the food chain, means that water availability is an important factor in farm decision making. This may become an increasingly critical factor for more farmers in the future, in determining their ability to adapt to changing policy at the national and international level. Already changing E.C. farm policies (MacSharry Proposals) are increasing the pressure on farmers to diversify their agricultural income. Given the nature of agricultural resources in the region, farmers may be pressurised to opt for the production of high value crops, such as onions and carrots, with thier associated increased requirements for water. The publication of the House of Commons Report (1992) on the Food and Drink Trade Gap, indicates a £6 billion deficit in 1990, of which

63% of this is made up of indigenous produce. This clearly has implications for water resource management.

4. INDUSTRIAL AND URBAN VALUES IN USE

4.1 Introduction

This chapter seeks to explore, first, industrial demands for directly abstracted supplies and second, the components which comprise the derived demand from water undertakers. Accurate determination of average and marginal values in use would require the construction of a whole set of demand curves for each type of water use (including unaccounted for water) and each distinct category of user. It was clearly far beyond the scope of this project to attempt such a construction exercise through new empirical research. Nor was it possible to determine detailed demand schedules using data from secondary sources; publicaly available material on the demand characteristics of these usage sectors is still extremely limited for Britain. At best the values in use presented in this chapter are indicative of the real situation.

Information on 'urban' demands for mains water supplies is taken entirely from the literature, much of which describes overseas experience. Initially, it had been hoped to supplement the limited UK based information on domestic demands by analysing the raw data emerging from the water metering trials; this has not proved possible. The Office of Water Services has only recently obtained copies of this potentially valuable data set; it is anticipated that future work on this material and on customers with optional meters will in time help to advance our knowledge of differential use values by consumer category and of differential price elasticities. Until they are available, information can only be described as rudimentary.

Published evidence on the demand from industry for directly abstracted supplies is even more fragmentary. Overseas evidence is sparce and often highly industry type specific and the only two known systematic analyses of the subject in Britain

(Rees 1969 and Herrington 1972) are now both extremely dated. Paucity of recent information is a serious limitation since it is known that industrial abstraction demand is highly sensitive to alterations in the industry mix and to changing process technologies. Given the degree of industrial restructuring which occurred in the 1970s and 1980s, earlier demand data may have little present day relevance. It was, therefore, felt to be important that some new information on industrial abstraction was gathered as part of the field investigations for this project, and a sample survey was, therefore, conducted in the Severn-Trent region the Colne and Cam and Rhee catchments (see 4.3).

4.2 Published Evidence on Industrial Value in Use

4.2.1 Overseas Evidence: Demand/Price Schedules

Relatively little useful and generalisable value in use information has emerged from the scant number of studies which attempt to estimate aggregate price/demand relationships from actual abstraction quantity and water price data. This is not unexpected, since in most countries abstraction water charges are minimal, normally being confined to nominal access fees which barely cover the administrative costs of the licensing systems. Where volume related abstraction charges have been implemented, prices typically are low, being cost recovery based and frequently levied for re-distributive reasons. Direct demand estimation exercises are complicated by the composite nature of the demand schedules for individual firms (ie made up of different quality components satisfied from different sources - see Olson 1966) and by the common practice, particularly in the United States and Canada, of levying abstraction charges using declining block tariffs. Further problems arise, for cross-sectional analyses, if the charging base varies from area to area, with some based on authorised quantities, some on actual abstraction, others making a distinction between abstraction and consumption (with different methods employed to calculate 'restitution coefficients') and still others employing different seasonal pricing structures.

Finally, but crucially, studies which simply employ the price paid for the water in the construction of the demand curves, ignore the fact that such prices are frequently only a proportion of the total cost involved in obtaining a usable supply. Other costs include pumping from source, transfer to plant, treatment to acceptable quality and any surplus water discharge fees. Large scale cross-sectional and time trend studies simply ignore these additional costs, since detailed industrial survey work would have been necessary to obtain the required data. All these problems not only help explain why few empirical studies on aggregate industrial water demand schedules have been attempted, but also mean that the results from those that do exist have to be treated with caution.

Notwithstanding these problems, all known studies serve to highlight two important features about industrial demand. First, there is no meaningful single demand curve for industrial abstractors as a whole. Demand varies enormously across and within industrial classification groups, reflecting in particular differences in manufacturing processes and the purposes for which water is employed. Use value is also dependent on supply quality, but the significance of quality varies with process, water-end use and the already installed treatment equipment within individual firms. Therefore, for practical planning purposes disaggregated industry specific, purpose specific and locationally specific data are necessary.

Second, water costs are always a minimal element in the total cost structures of industry. (This is in part, of course, due to the pricing strategies of the agencies responsible for water resource allocation). Even for large water using primary and heavy secondary industries, it would be unusual for water to account for more than 0.2% of total manufacturing input costs. This means that choices about water use are secondary to decisions on process technology, material inputs, output mix and the scale of operations. There is also some recent evidence that suggests that water use decisions are also secondary to pollution control cost, abstraction levels and recycling investments being strongly influenced by discharge conditions and waste water charges. In these circumstances, it is not surprising that most (but not all) known studies have either failed to establish any price/demand relationship, or have concluded that industrial demand is relatively inelastic (De Rooy, 1974; Brebenstein and Field, 1979; Stone and Wittington, 1983).

4.2.2 Overseas Evidence: Surrogate Value in Use Measures

Theoretically, a whole range of surrogate value in use measures could be employed to establish values for industrial abstraction as they have been in the irrigation case. In practice, however, all known studies have employed one technique, namely, equating the value of raw water with the internal cost of water recycling, including the treatment costs incurred prior to reuse. Attempts to calculate the value added by water (analagous to the agricultural gross-margins approach) have not been employed for industrial use largely because of the way that differences in water inputs are swamped by variations in other variables. It is less easy to explain why our literature search revealed no attempts to assess maximum abstraction water values by analysing the cost of metered mains water (normalising for quality differences) as the 'next best alternative' to direct abstraction, nor why there are apparently no studies using hedonic pricing or contingent valuation techniques.

The use of internal recycling and treatment costs as a value measure rests on the assumption that a rational cost-minimizing manufacturer will not be willing to pay more for 'new' water than it costs to produce additional supplies via reuse. Clearly this approach cannot be used when the abstracted supplies are incorporated into the final product. In the vast majority of studies using this technique the capital availability constraints facing industry are typically ignored, as are the possibilities that producer objectives need not conform to those assumed to be economically rational (see Chapter 7).

Reuse costs vary depending on the purpose for which water is used; in particular a distinction needs to be made between cooling and process water. Most studies have established water re-circulation cost functions of the type shown in Figure 4.1, although in practice the curves are rarely smooth but involve a series of steps as specific recycling and treatment technologies come into play.

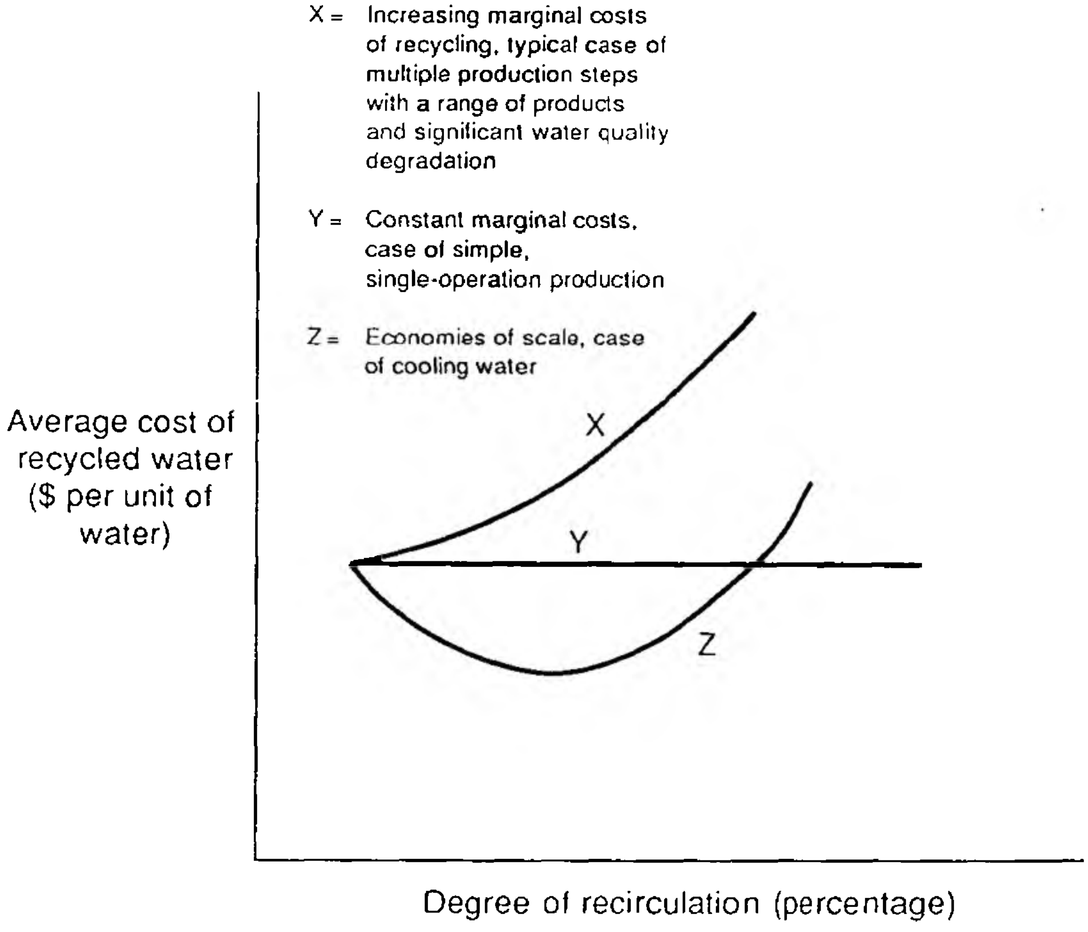


Figure 4.1 Water Recirculation Cost Functions. Source: Blair T. Bower, "The Economics of Industrial Water Utilization," in Alleb. Knees and Stephen C. Smith, eds., Water Research (Baltimore, Johns Hopkins University Press for Resources for the Future, 1966) p.164.

Process water recycling is typically more expensive than cooling water reuse since more treatment is involved prior to reuse. Moreover, there are wide cost variations between firms depending on the process technologies employed and on the specific pollutants absorbed by the water during processing. Young and Gray (1972), for example, gave estimates of marginal process water recycling costs (and thus of the marginal value of new abstraction water) which ranged from $16 per acre foot‡‡‡ in the minerals sector to $51 and $64 in the chemical and paper industries respectively. Russell (1970) established a higher figure of $75 per acre foot for the beet sugar processing industry. Even higher values were produced by Kollar, Brewer and McAuley (1976) for the cotton textile finishing and dyeing industry. They argued that the marginal cost curve was stepped. To increase the recycling rate from 48 to 76% of gross water input the cost would be $133 per acre foot, but the next step of recycling to 85% would involve a marginal cost of $627 per acre foot; the remaining 15% of gross water input was consumed by use - its value would be enormous since no production was possible without it. The latest known study of this type was conducted by Kane and Osantowski (1981) for one meat packing plant, where the marginal costs of recycling ranged from $327 to $456 per acre foot depending on the amount of blending necessary to achieve stringent quality requirements. All these figures are, of course, now dated and they critically depend upon the process and treatment technologies available at the time of the study. Moreover, they all suffer from the problem that it is difficult to disaggregate the implied value in use of the raw water from the costs incurred to meet pollution discharge standards.

Cooling water reuse cost estimates are generally low when moving from once-through systems to the use of evaporative cooling towers, which can reduce raw water inputs by as much as 97%. Figures quoted in Gibbons (1986) from various sources and expressed in 1980 US dollars per acre foot ranged from $5 to $11 for electricity utilities and petroleum refineries. These costs, however, escalate to $618 if de-mineralization and reuse of blowdown is employed (processes which save less than 1% of total water input). Even higher costs of between $933 and $1,300 are incurred if dry cooling systems are employed. Clearly their use implies extremely high value in use for water and they are only employed in extremely arid areas, where electricity generation is tied to the location of the fuel stock (specifically coal) by high transport costs.

One further study using the 'next best alternative' methodology warrants mention here. This was a much more aggregate exercise conducted by Muller (1985), which attempts to place economic values on water used for a range of purposes in Canada. His estimates which do not distinguish between cooling and process uses, range from Can $16 per million litres, for primary industry, up to $124 for food and beverage producers. These figures are all averages and not marginal values.

None of the surrogate value in use figures presented in this section should be viewed as anything other than indicative of the broad range and level of values which could be encountered in the United Kingdom. They do, however, suggest that the marginal value in use of water used in once through cooling systems will be low and, therefore, that the longer term price elasticity of demand for abstraction water for this purpose will be high as new capital investment is made. For process uses, where recycling costs are typically much higher and decisions on process technology are rarely made on water price criteria, the expectation is that value in use is much higher and that the demand elasticity, at least in the short term, will be very low.

One very important feature does, however, emerge from the overseas research, which could have critical implications if the NRA embarks upon an incentive based abstraction charging system. This is that the individual plant demand curve is stepped; at particular but variable water prices it becomes economically worthwhile to invest in the next available water saving technology, but between each of the steps demand is completely unresponsive to price changes (see Figure 4.2). Such steps or kinks in the demand curve were also thought to occur for irrigation abstractors (3.2.2) but are far more important for industry, first because the steps typically appear to be larger and second, because large industrial abstractors tend to be more scattered in their locations. This last point means that for most catchments there will not be enough firms for the demand curve to be 'smoothed' by aggregating together the various individual curves with steps occurring at different price points. Thus for NRA planning purposes it will usually be very important that the authority has good knowledge of the steps that apply for particularly large industrial abstractors.

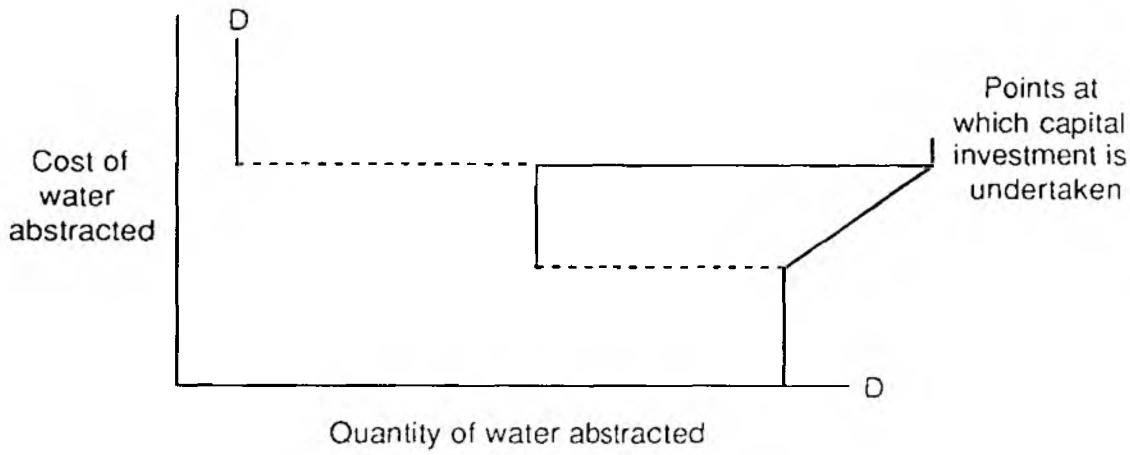


Figure 4.2 Stepped Abstraction Demand Curve.

4.2.3 UK Evidence

As already indicated this evidence is extremely limited and dated; we do not even have anything other than rudimentary knowledge on such basic issues as how much water is abstracted by which industry groups for what purposes. Although analysis of NRA abstraction records could provide some useful information, it would be an enormous task. By no means all NRA regions have fully computerised records. Where information on industry group or water end purpose has been collected (usually on the licence application or on licence revision) the data, from our experience, can be years, even decades, out of date and it is rare for any records to be held on the process, employment and technological characteristics of abstracting firms.

As far as we have been able to establish from a search of the published literature, no substantive studies have been made on industrial abstraction for twenty years; clearly this early work has extremely limited relevance for the estimation of present day value in use. It is, therefore, only necessary here to highlight the key features from this work that might have significance today.

First, it supports the overseas finding that water is a minor cost element within industrial cost structures. Further it shows that marked demand variations exist both within and between industry groups, depending on the specific processes employed, the nature of the final product and the raw material inputs, the use made of the water and on the capital equipment inheritance of firm.

Second, not unexpectedly because of the exceptionally low abstraction charges, few significant relationships could be established between price and quantity abstracted. However, for some industrial groups, most notably drink, paper and chemicals, questionnaire responses indicated that significant price rises would result, in the longer term, in investment in recycling technologies. Since the longer term can mean 20 or more years, price rises are likely to be a blunt instrument in any attempts to curb water abstractions speedily.

Third, demand for metered water was highly responsive to price for some industry groups (particularly food, drink, non-metallic minerals and paper) and, interestingly, the elasticity of demand was generally greatest for those firms with access to privately abstracted supply sources. This last point suggests that mains and abstracted water are substitutable at the margin, so lending credence to the idea that the price of metered water provides one measure of the maximum value in use of abstraction supplies, after the costs of pumping from source, transport to plant and treatment costs have been taken into account. It also might suggest that where metered water charges have been rising rapidly, there will be an increased demand for abstracted supplies.

4.3 The Industrial Survey

4.3.1 Introduction

The small scale survey of industrial abstractors conducted as part of this project will not yield results which are generalisable to all industry groups over England and Wales as a whole; nor was it designed to do so. Notionally, NRA abstraction records were a potential source of data from which to establish aggregate demand/price relationships using cross-sectional and time trend regression analysis. In practice, even with unlimited resources, such an approach was unlikely to yield meaningful results. Given the relatively low abstraction charges, the limited real price rises over time, and the minimal contribution which water plays in industrial cost structures, time trend work was almost certain to have failed to disentangle the effect of price from the major changes in water usage created by alterations in industry structure, process technology and output levels. Cross-sectional aggregate studies would have been equally problematic given the nature of NRA records, the small range of prices and the low price levels. To obtain a generalisable picture of industrial water use a very major empirical exercise would have been necessary to allow investigation of industrial production functions and the costs of water saving technologies for different types of firm.

Although the industrial survey work was designed to attempt to derive some indicative values in use information, there were wider objectives. In particular, attention was paid to exploring the realities of manufacturers' water using behaviour, their likely response to the NRA's potential use of economic incentives, the variables underlying water consumption, re-use and discharge decisions and any constraints inhibiting 'rational' responses to water or effluent discharge price signals. These important behavioural issues will be discussed in more detail in Chapter 7, but inevitably reference to them will be made when the results of the industrial survey are presented below.

4.3.2 The Sample

As explained in 1.2.1, the original intention had been to take as a sample frame all industrial abstractors within four overabstracted catchments selected, in consultation with the NRA, for study. This yielded far too few industrial concerns to obtain any meaningful results for the demand sector. Therefore, although all manufacturers in two catchments - the Cam and Rhee and the Colne - were included in the sample, an additional group of firms in the NRA Severn Trent Region were added. These were manufacturers taking abstracted supplies from the British Waterways Boards' canal system; although NRA licences were required for these abstractions they were held by the BWB who then supplied water to the final user under contract.

There were two basic and related reasons for including BWB abstractors in the survey. First, the Board was known to charge abstractors on an NRA costs plus basis and to employ a variety of tariff structures. The level of the plus factor depends on both the date of the abstraction contract and on the nature of that contract. Before 1986, the apparently general, but by no means universal, rule was to set canal water prices at approximately one third of the cost of potable piped supplies. Since then contracts have been more closely geared to what the abstractor will pay and there is no one fixed price. The existence of a range of prices raised the possibility that greater insights would be obtained into the industrial demand curve than if the sample had only been drawn from those directly taking supplies from the NRA. Moreover, given the BWB's cost plus charging base the canal water charges should have been significantly higher than normal abstraction charges and thus any effect of price on consumption should have been more readily discernible. A second reason for looking at the BWB group of abstractors related to the supply reliability question. Canal supplies were thought to be generally more reliable than those from un-augmented NRA surface water sources; indeed some BWB contracts contain reliability clauses which involve charge rebates if supply failures occur. Therefore, it might be possible to establish how far abstractors saw the higher canal charges as being offset by improved reliabilities.

	ALL AREAS	B.W.B	COLN	CAM-RHEE
POPULATION	156	76	57	23
REFUSALS	26	13	9	4
UNABLE TO CONTACT	16	10	3	3
NO TRACE	32	10	19	3
TOTAL SAMPLE	82*	43	26	13

Table 4.1 Regional Breakdown of Industrial Sample.

It was decided to include the total population of 156 firms in the survey in order to obtain an eventual sample size which would allow some disaggregation into industry types. In fact it was only possible to administer the full questionnaire to 82 concerns, for reasons summarised in Table 4.1. The number of firms refusing interviews was relatively small but this was swelled by a group, which agreed to participate in principle, but failed in practice to either nominate a suitably qualified interviewee or set an interview date. Another group had to be dropped from the sample since they were impossible to trace. This was particularly a problem for the BWB held licences, where the licence gave a grid reference and, at best, a vague company name and address. When searches through relevant telephone directories failed to pinpoint the licensed company, field investigations were conducted. It rapidly became apparent that the abstraction licence records were highly dated. In a significant number of cases factories were derelict (even demolished), were empty and for sale, had been re-developed for non-manufacturing purposes, or had changed ownership, with the new owners not using abstracted supplies and often unaware of the existence of a licence. The British Waterways Board are evidently retaining a large number of currently unutilized licences probably as part of their new 'commercial' approach to canal re-development and water marketing.

PART A: INDUSTRIAL TYPE	
CLOTHING-TEXTILES	20 (26%)
METAL PRODUCTS	19 (24%)
NON METALIC MINERALS	7 (9%)
CERAMICS-POTTERY	6(8%)
CHEMICALS	4 (%%)
PLASTICS-RUBBER	4 (4%)
OTHER	18 (23%)
PART B: STRUCTURE	
SINGLE PLANT	21 (27%)
MULTIPLE	57 (73%)
PART C:NUMBER OF SITES	
5 SITES	16 (28%)
5-20 SITES	19 (33%)
OVER 20 SITES	22 (39%)
PART D: NUMBER EMPLOYED	
UNDER 500	61 (78%)
500-1000	6 (8%)
OVER 1000	11 (14%)

Table 4.2 Industrial Size and Structural Characteristics of Sample Firms.

The size and general industrial characteristics of the surveyed firms are summarised in Table 4.2, while their water using characteristics are given in Table 4.3.

PART A: TOTAL WATER CONSUMPTION BY INDUSTRY GROUP	UNDER 50 MEGALITRE S PA	50-100 MEGALITRE S PA	OVER 100 MEGALITRE SPA	DON'T KNOW TOTAL CONSUMPTION		
CLOTHING-TEXTILES	6	3	5	6		
METAL-PRODUCTS	10	1	6	2		
NON METALIC MINERALS	2	1	3	1		
CERAMICS-POTTERY	1	0	0	5		
CHEMICALS	1	1	1	1		
PLASTIC-RUBBER	0	2	2	0		
OTHER	3	4	2	9		
	23	12	19	24		
PART B:MAINS WATER USE BY INDUSTRY TYPE						
CLOTHING-TEXTILES	12	1	0	7		
METAL PRODUCTS	12	1	2	2		
NON-METALIC MINERALS	3	0	2	2		
CERAMICS-POTTERY	1	0	0	3		
CHEMICALS	2	1	0	1		
PLASTICS-RUBBER	0	1	2	1		
OTHER	5	2	1	14		
	35	6	7	30		
PART C:TOTAL MAINS WATER USED, BY % USE BREAKDOWN	DOMESTIC	PLANT CLEANING	WASHING	BOILER FEED	IN PROCESS	COOLING
ZERO	1	74	75	65	65	65
UNDER 50 MEGALITRES	14	3	1	9	5	8
50-100 MEGALITRES	6	0	1	3	6	4
OVER 100 MEGALITRES	14	0	0	0	1	0
DONT KNOW CONSUMPTION OR USE OF MAINS WATER	43	1	1	1	1	1

Table 4.3 Water Consumption Characteristics of Sample Firms.

4.4 Establishing the Abstracted Water Price

Before considering some of the results obtained from those parts of the survey concerned with value in use, and supply reliability, it is essential to address the critical problems involved in establishing what firms were actually paying for their abstracted supplies.

For firms taking supplies directly from the NRA the price of the authorised supplies could be established from the charging schedules. As was done in the farm survey, the firms were questioned about these charges to check how aware interviewees were of the price reality; clearly knowledge of price is an important pre-condition for 'rational' response to it. However, simply taking the price of water to be the NRA charge raises two problems. First, the charges are based on authorisations and not on actual consumption: therefore the effective price paid for each unit of supply taken varies between firms depending on the ratio of actual to authorised usage. This limited the reliability of the price variables employed in multiple regression analyses which attempted to 'explain' industrial water consumption. Conceptually, it is possible to regard the differential unit water prices as some minimal measure of the willingness of firms to pay for unused authorisations as an 'insurance hedge' against uncertainty. In practice, however, only a small proportion of companies even attempted to rationalize their retention of un, or partially, used licences in this way.

The second, and rather more fundamental problem arising in attempts to establish the water price, occurs because water charges are only one element in the cost of getting a usable supply into the plant. Capital and recurrent per megalitre costs of pumping and transferring the water from the abstraction point to the place of use need to be included, as also do the costs of treatment. Without these additional cost elements it is difficult to make valid comparisons between the relative costs of mains, canal or NRA abstraction sources, and of water re-use. However, as Tate and Robichaud (1973) have pointed out there are methodological problems in assuming water costs are a surrogate for price when attempting to establish demand curves. Moreover, on a purely practical level, there were considerable difficulties in getting reasonable cost information from firms. None of the surveyed companies had reliable data on the past capital costs of intake facilities, although one had information on the costs of a proposed new borehole. In most cases, source work had been undertaken many years ago and had long since been depreciated off the books of account. Similarly, no firm was able to estimate the running and maintenance costs involved; labour and power were not charged to any distinct 'water' account but were simply aggregated into general plant operating costs. Inevitably these costing difficulties affected attempts to employ the 'next best alternative' approach to value in use estimation (see 4.5).

Additional problems were encountered in attempting to establish a price/cost for BWB supplies. Information on the general charging practices adopted by the BWB was obtained from the Board, but no data on the details of the price faced by each surveyed firm was available. The accuracy of our price information is, therefore, dependent on the responses from the firms themselves.

In general, for all but the largest firms, BWB charges are set on the following basis:-

(a) NRA licence charge (authorised)

plus

(b) BWB standing charge

plus

(c) Volume charge (actual use)

Standing charges or fixed charges (a + b) currently account for approximately 50% of the total payment but this proportion can be higher in new and revised contracts. It is BWB policy to increase the fixed charge element in their tariff structures, which, although financially advantageous to the Board, clearly runs counter to the use of price as a demand management tool. In most cases the standing charge gives firms a 'free' water allowance, and volume charges only come into play once this allowance is exceeded. Contracts currently operate for a minimum of 3-4 years up to a maximum of 25 years, but older contracts may be for much longer periods, including some 'evergreen' arrangements.

In all but historic contracts, the charges are automatically adjusted for inflation, but unfortunately matters are complicated by the fact that a range of inflators are used. Typically contracts made over three years ago will employ the BWB labourer's wage rates as a price index. Today, however, the choice of inflator will be part of the bargain struck with individual firms; in some cases RPI will be employed, in others the industry specific producer price index is adopted. At present consideration is being given to the use of 'K' factors in the charge formulae if BWB is involved in investment to ensure the abstraction. While the above arrangements are now the norm, even for new contracts quite different conditions can apply, including simple annual flat rate fees, discounts for returned water and payments for any return flows. Adding still further to the complexity is the fact that for larger abstractors the volume charge is typically levied according to a declining block tariff, with variable return factor rebates.

When attempting to equate the prices paid as reported by the firms with the BWB general charging system it rapidly became apparent that there were major discrepancies which could not be explained by the age of licence contract. A significant number of firms appeared to be paying less than they would have been if taking the same authorised quantity directly from the NRA. While this feature was explainable for historic contracts, it made no sense at all for new and revised agreement. It was, of course, recognised that some abstractors could simply be mistaken about the real charge levels, but too many firms were affected for this to be the sole, or indeed the major, explanation. Only at this stage was it established that the NRA regions give the BWB major discounts, in the Severn Trent case ranging from 87.5% to 64% depending on the stretch of canal, on 'normal' licence charges. The economic justification for such discounts remains unclear; they undermine the already weak price signals contained in the NRA's charging scheme and in effect simply transfer revenue from the NRA to the BWB. Inevitably, the existence of this discounting procedure removed the rationale for including canal licence holders in the industrial survey. Not only did few above NRA price points emerge, but also the firms were paying no more (and often much less) for the greater reliability of canal abstraction.

In view of the difficulties involved in establishing the full costs of abstracted supplies and of the fact that BWB prices were rarely any higher than 'normal' NRA abstraction prices, it is hardly surprising that only one significant relationship could be established between abstracted water prices and either actual or authorised consumption. This relationship was for the actual canal usage by abstractors and the sign was positive; in other words we were merely observing the combined effects of high fixed charges plus declining block tariffs on the price paid for different quantities of water.

4.5 <u>Value in Use and Reliability</u>

4.5.1 Alternative Methodological Approaches

Three distinct methodological approaches were adopted in attempts to derive some value in use estimates. First, the 'next best alternative' method (see 4.2.2) was employed. To obtain the necessary supplies of water, industry notionally has a choice of three sources, which it can employ in some combination - mains supply, direct abstraction and capital investment in recycling or other water saving technologies (including input, process and product change). Our basic intention was to attempt to place costs on these alternatives and, taking into account the fact that they were not perfect substitutes for all end uses, employ the cost differentials as crude value in use measures. In addition, it was hoped that study of the costs of already installed water saving technologies would allow some insights into the implied value of 'new' water and the responsiveness of firms to price.

Second, an attempt was made to use contingent valuation to investigate future potential reactions to increases in both water abstraction and mains water prices, to gauge the willingness of firms to pay for increased supply reliability, and to assess their reactions to the introduction of a tradeable permit system. Finally, an effort was made to employ the hedonic price approach to measure the value of an abstraction authorisation. Firms in the main survey were asked about their past experience of any site value enhancement effect; industrial property agents were approached to provide details of any land value differentials and a telephone survey of unutilized licence holders was conducted to establish the reasons for licence retention.

4.5.2 Next Best Alternative Measures

Too few of the interviewees possessed enough reliable cost information to make any statistical analysis meaningful, although it was possible to obtain some limited data from case examples.

As discussed in 4.4, it was not possible to establish the real cost price of abstracted supplies. Moreover, under 25% of all the surveyed companies had installed any form of water recycling and this was normally, but not exclusively, employed to re-use mains supplies. Only one firm, a major chemical company, could provide any meaningful past cost details. Further, it became clear that reduction in water supply costs was never the only, and rarely the most important, motive behind the introduction of recycling. For three companies, mains water costs were cited as an important factor in past decisions, but interestingly (see below) increases in company charges were beginning to focus heavily (for larger companies) in planned investment options. Three basic reasons were given for existing re-use investments. First, recycling facilities were simply part of the standard process technology package purchased by the company. Second, re-use was employed to reduce trade effluent charges (for discharge to sewers) and to comply with discharge conditions set for both sewers and rivers. Third, some firms were re-using water to conserve energy, in other words they were recycling heat not water.

Somewhat counter to expectations, more (but still a small minority of) interviewees were able to give detailed cost information in response to the contingent valuation questions concerned with their reactions to future water price rises and pollution control regulations. This arose in part because the managers interviewed were less concerned with decisions made by their predecessors than with choices they themselves might have to make. But in 12 of the surveyed firms (all but three branches of multi-plant companies) a major re-evaluation of their water using practices was either in progress or was planned. Not unexpectedly abstraction water charges were not cited as a reason for this re-evaluation. Five main reasons were given.

First, current metered water charges and expectations about significant real term price rises over the next 5 years were leading to re-appraisals of the viability of recycling and other water saving technologies (including in plant leakage control, low water toilet flushing systems, and a water awareness campaign). In addition, and of potential importance to the NRA, moves are being made to substitute mains supplies by the unused portions of existing abstraction licences and, in one case, by the application for a new borehole licence.

Second, future trade effluent charges, fears about more stringent river quality standards and potential pollution 'taxes' were producing increased interest in recycling.

Third, one firm (a major multi-national user of canal water) cited environmental health reasons for the installation of more sophisticated, water efficient, closed circuit compressor cooling systems. Dangers associated with weils disease, legionella, faecal coliforms and blue green algae were the justification for the proposed investment; minor water cost savings were simply a bonus. {It is perhaps worth mentioning that for this firm the cost savings were actually higher than they would be under a normal NRA tariff, since under the BWB contract the water price was higher if the supply was returned to source}.

Fourth, for four firms, additional water treatment was necessary to maintain or improve product quality in the face of increased source pollution or unacceptable supply quality variations (fluctuations in the hardness of mains supplies, for example); this prospective investment was prompting re-appraisal of the whole water use 'package'.

Finally, the firm developing the most sophisticated package of water conservation measures saw water cost reduction as part of a system of cost control within the plant as a whole; energy costs, waste water discharge costs, and residuals reclamation were all partially dependent on water use decisions. In order to encourage conservation an internal cost allocation scheme has been devised which charged each cost centre for 'new' water used at a rate of £2.50 per 1000 gallons.

4.5.3 Some Cases of Alternative Supply Costs

It must be stressed that substitution options were only being actively considered by a very small group of firms, although all were significant water users. Another eight firms had taken a conscious decision not to install re-use or other water saving technologies because of the cost of capital and capital availability constraints. However, the majority of firms in the sample were on a sort of water use 'auto pilot': change in past practice was simply an unconsidered option. Some confirmation of this feature comes from the fact that only 20% of the sample would even think about water economy measures if they were faced with a 50% real increase in mains and/or abstraction water prices.

Therefore, the following cases cannot be taken as in any way representative of firms as a whole.They do, however, give some insights into potential water using practices and, albeit extremely crude, indicators of abstraction water value in use.

Case A: Large Multi-National Ceramics Company

Problem(s): Unreliability of bore hole supplies plus high trade effluent bills.

The failure of the borehole to yield the required supplies necessitated the substitution of mains water at £644.00 per megalitre. This represents the maximum marginal value in use of abstracted supplies. In one year borehole unreliability cost the company over £750,000.

Solution: Planned recycling of 75% of all water (mains and abstracted) used in the plant. Discounting the capital over a three year period and assuming a 5% real cost of capital, the value in use of abstraction water as measured by recycling was £2.77 per megalitre. It should be noted that this is only marginally higher than the current £2.31 per megalitre authorised abstraction charge. If the capital costs were annualised over the expected 20-25 year life of the recycling plant (and assuming a 5% real cost of capital) the per megalitre cost is reduced to under £0.70.

However, the company was not able to estimate the additional recurrent costs of running the recycling system, which means that our figures deflate the real value in use of 'new' water.

On the other hand, recycling will reduce the volume related trade effluent charges by £174 per megalitre, but some increase in strength charges will reduce this figure.

Comment: Even before problems were encountered with supply reliability, water recycling would have markedly reduced the total water in/waste out costs for the company. However, unreliability threatened production, the problem became a technical one which could only be solved in the short term by mains water use. This problem produced a comprehensive review of total water use and the planned introduction of recycling. The full licence is unlikely to be re-negotiated while charges are set at current levels; the licence represents a very low cost insurance policy.

Case B: Large Multi-Plant Textile Company

Problem: Unreliability of borehole abstraction water for in-plant process use.

Mains water had to be employed to make up the short fall. At a mains water price of £412 per megalitre, unreliability of the abstraction source cost the company almost £150,000 per month.

Solution: Before the unreliability problems were encountered recycling had been considered but capital costs and availability constraints had forced a postponement of the decision.

Reappraisal of the situation is now occurring.

Assuming a 3 year depreciation period and a 5% real capital cost, recycled supplies would cost £17.55 per megalitre [plus operating costs]. If the capital cost was spread over the entire 25 year potential life of the equipment, the per megalitre cost fell to £4.12 per megalitre.

In addition a potential saving of £130 per megalitre [minus increased strength charges] could be made on the trade effluent charge.

Comment: Even before the unreliability problems, recycling was viable if water and waste water costs were considered together.

Recycling to save abstraction charges alone was not economic at current price levels if full reliability could be guaranteed. But as soon as mains water top up has to occur the capital cost of recycling could pay for itself within 6 months.

Case C: Multi-National Engineering Company

Problem: Increased mains water costs and trade effluent charges

Solution: The company is switching from total mains water use to a combined abstraction (river) plus mains system. An un-utilized but extant licence is being re-activated. Abstracted water will be treated and recycled to reduce mains water use by 30% and the volume related trade effluent costs.

Assuming a 3 year pay back period (5% real cost of capital) the cost of recycling was £511 per megalitre, but this reduced to £120 per megalitre if the capital costs were annualised over a 25 year life of the equipment. The first figure suggests that the switch would already be economic at current mains water prices. However, the company expect further real price rises and would also save approximately £174 per megalitre (minus increased strength charges) on their trade effluent costs.

Comment: If more companies start to respond to rising mains water costs in this fashion, the NRA might expect to see demand for actual abstraction increasing, although authorised volumes might not do so if licences are already held.

Case D: Multi-National Metal Product Company

Problem: Increases in mains water costs

Solution(s): Three options are currently under investigation:-

(1) Changing the current supply source mix from 80% mains - 20% canal abstraction to 80% abstraction - 20% mains. Treatment facilities would be necessary.

(2) Develop ground water sources utilizing a licence unused for 25 years, necessitating less treatment, but involving reliability problems. The costs of investigating the location and reliability of the potential source were considered to be high. However, the option would be very low cost.

(3) Increase the level of recycling and switching away from mains supply. Recycling of canal water was, however, regarded as potentially hazardous with the possibility of contaminated supplies entering highly sensitive process systems. This was not, therefore, a preferred option.

On the capital costs provided by the company the treatment of canal water would cost £0.53 per megalitre (3 years) or £0.124 per megalitre over 25 years. Clearly this is exceptionally low compared with the mains water cost, although the additional running costs of the treatment plant and the price of the canal water need to be taken into account.

Ground water, requiring much less treatment, would be the lowest cost option at £0.05 per megalitre (over 3 years), but reliability was a key issue and the company have rejected this option. This gives us a very crude measure of the price the firm was prepared to pay for reliability - namely about £0.50 per megalitre.

Case E: Multi-National Chemical Company

Problem: Variability in the hardness of mains water creating processing problems and necessitating the installation of treatment.

Solution: As treatment was now necessary for mains supply, the possibility of using bore hole water with a new licence was investigated. The additional cost of treating bore water (over the treatment for mains) was only £0.56 per megalitre (3 year depreciation period). Since mains supply costs over £640 per megalitre and the bore supply £2.31 per authorised megalitre, the switch to ground water pays for itself within weeks!!

Comment: This is a classic example of a firm which did not question water costs until a technical problem arose. Once challenged to rethink their water use strategy major cost savings were possible. This has implications for the NRA if other firms also attempt to switch from mains to bore holes.

Case F: Multi-National Metal Product Company

Problem: Mains water costs plus trade effluent charges.

Solution: Switch supply sources to borehole and increase recycling to produce an 11% reduction in mains water use in the short term.

Eventually increase the percentage of bore hole supplies and introduce the use of canal abstraction water. In the short run an existing partially utilized bore hole licence can be utilized. Further switching would require new licences.

The capital costs of employing the bore hole and a small measure of recycling would come to £0.51 per megalitre (3 year discounting period).

Comment: Once again with the enormous differential between mains water costs and abstraction supplies it is difficult to see why the switch was not considered earlier.

Case G: Multi-National Metal Products Company

Problem: Environmental health problems associated with the use of canal water.

Solution: Switch cooling water use from canal to mains and introduce recycling.

The capital costs involved will alone reach £69.43 per megalitre (over 3 year depreciation period) or £16.30 per megalitre (25 year depreciation). However, given the decision to move from canal sources to avoid environmental health risks, recycling is evidently a cost effective option compared to the price of 'new' mains supplies.

4.6 Reliability

With the exception of the three firms discussed in cases A, B and D above, supply reliability was an unconsidered issue for the surveyed firms. Although 40% of the companies had invested in storage at some time in the past no firm claimed this had anything to do with source reliability per se: achieving a sufficient head of pressure and safeguarding against temporary failures of pumping equipment were the normal explanations. None of the companies taking

BWB supplies saw reliability as a reason for using a canal source, nor did any of the firms perceive part of their water charge to be payment for the additional security associated with canal supplies. No firm, even those which had problems with borehole supplies, was prepared to pay for improved reliability of supply. Rather unexpectedly, licence holders in the over-abstracted catchments of the Cam and Rhee were no more sensitive to reliability issues than were firms elsewhere, despite the fact that water shortage problems and the fate of over-abstracted catchments had featured quite heavily in the media at the time the survey was undertaken.

4.7 Value of an Abstraction Licence Using Hedonic Prices

Unlike the irrigators surveyed, manufacturers appeared not to have any clear ideas about whether the existence of a licence enhanced site values. In part this result may simply reflect the position within the company and the professional competence of the interviewees; for the most part they were technical managers. However, the small scale survey of 10 industrial property valuers, located in Birmingham and Cambridge, suggests that water availability (and thus the existence of a licence) was an insignificant factor in determining land values. The only possible exception to this would be for very large water using companies, which would set water availability as one of the necessary characteristics of a potential site, along with labour availability, other infrastructure and so forth; however, the price paid for the eventually chosen site need be no higher because of its water supply. This view was echoed by a representative of the Royal Society of Chartered Surveyors.

It is easy to understand why abstraction licences should have no apparent value in the Birmingham region; there are numerous vacant canal side sites with available licences and increasing ground water levels means that there are generally few restrictions on the issue of new borehole licences. Interestingly, the agents selling the sites identified in the field survey as being on the market were not even aware that the properties had the benefit of licences of right. However, new licences are a much more scarce commodity in the Cambridge area; in this case it seems likely that the growth industries seeking new sites are not significant water users and thus their requirements are met from mains supplies. Unfortunately, it was not possible to explore this matter further by surveying firms which had failed to acquire a licence. As explained earlier most potential abstractors never make a formal licence application but are 'rejected' at the informal inquiry stage and as far as it could be established no NRA region kept data on such informal refusals.

The telephone survey of companies retaining totally un-used licences basically served to reinforce the message coming from the other parts of the study. Nine of the contacted firms were unaware that they held a licence; presumably the licence charge was too insignificant for the bill to warrant scrutiny in accounts departments. Two firms, now using only mains water, retained the licences on a 'just in case' basis, while eight companies (all involved in aggregate extraction) held the licences to enhance production flexibility. If the market for aggregates improved in an area not only could the site with the licence be brought speedily into production but also gravels from elsewhere could be brought to the site for washing and treatment. The licence was also an advantage if at a future date the site was to be used for land fill.

4..8 Urban Price/Demand Relationships: Overseas Evidence

4.8.1 Introduction

The term urban demand is used to refer to supplies provided to final consumers by water undertakings. To obtain a good understanding of water demand relationships in this sector, disaggregated studies of the specific consumer groups contributing to the whole is desirable (Dziegielewski and Boland 1989). The different component groups vary in their water using characteristics, demand growth rates and responsiveness to price changes. Most commonly, three basic user categories are distinguished - residential, industrial and commercial; in recent years, however, some studies have separated government buildings, institutions (eg hospitals) and schools from the commercial category (Williams and Suh 1986; Schneider and Whitlatch 1991). A considerable literature now exists which analyses aggregate urban demand and the residential sector, but much more limited evidence is available on the other user classes.

Very little of this work has been concerned with value in use measurement per se, although, of course, the demand curve is assumed to represent the value in use of each quantity of supply to consumers. For the urban sector, however, the demand being expressed is for high quality, potable supplies delivered to the point of use; this is quite a different water product from raw water at the point of abstraction. Therefore, to obtain comparable value in use measures conversion into the same product is necessary (4.8.5). Given that urban supplies in the United States (was where much of the work emanates) are typically priced on a per unit basis, most studies have been concerned with estimating demand directly from actual charge and consumption data; very few have employed surrogate methods of assessing value in use. However, in recent years some work has been conducted which applies contingent valuation and subjective social indicators to assess the consumers' level of satisfaction and assign hypothetical monetary allocations to particular unpriced (or imperfectly priced) services (see for example Shin and Gregg 1984, Syme 1990).

It is important when considering urban demand to recognise that the water using behaviour of the final consumer groups is not simply dependent on exogenous variables, such as climate, income levels, the nature of the housing stock and so forth. Also relevant are the objectives, supply practices and pricing policies of the water retailers, the 'middle men' - the water undertakings. Most obviously their tariffs and policies on peak supply provision will have an influence on demand, as will the general message which they convey to consumers on the value of water and the need for conservation (Nieswiadomy 1992). In addition, up to 25% of total urban water usage is actually 'consumed' by the retailers through losses from the distribution system. It is, therefore, necessary to consider the potential behaviour of the water undertakings, when attempting to evaluate the feasibility of using economic tools for demand management. These behavioural issues will be considered in Chapter 7.

COUNTRY	TYPICAL ELASTICITIES	COMMENTS
U.S AND CANADA		
AGGREGATE DEMAND	-0.3 TO -0.8	CROSS SECTIONAL STUDIES
RESIDENTIAL (ALL SEASONS)	-0.25 TO -0.9	CROSS SECTIONAL AND TIME SERIES
RESIDENTIAL (WINTER)	-0.06 TO -0.3	CROSS SECTIONAL AND TIME SERIES
RESIDENTIAL (SUMMER)	-0.43 TO -1.5	CROSS SECTIONAL AND TIME SERIES
RESIDENTIAL (ALL SEASONS BY REGION)	-0.43 NEW ENGLAND	FOSTER AND BEATTIE (1979)
	-0.30 MIDWEST	
	-0.38 SOUTH	
	-0.58 PLAINS	
	-0.69 NORTH WEST	
	-0.36 SOUTH WEST	
AUSTRALIA		
RESIDENTIAL (WINTER)	-0.04 TO -0.36	TIME SERIES AND CONTINGENT VALUATIONS
RESIDENTIAL (SUMMER)	-0.3 TO -1.2	TIME SERIES AND CONTINGENT VALUATIONS
FINLAND		
MUNICIPAL ALL YEAR	-0.11	LAUKKANEA (1981) THIS IS THE ONLY KNOW STUDY OF ELASTICITIES IN EUROPE

Table 4.4 Price Elasticities for Urban and Residential Demands.

4.8.2 Aggregate Urban and Residential Demand Elasticities

Table 4.4 summarizes the evidence on the responsiveness of demand to price changes established by a range of studies (for reviews of this material see Hanke 1978, Boland et al 1984, Herrington 1987, Gibbons 1986). There are well known problems involved in interpretating and generalizing such elasticity results, particularly as they are critically dependent not only on the consumer and climatic characteristics of the areas studied, but also on the estimation techniques employed and on the level and definition of the price variable used. However, notwithstanding these problems, the data does suggest that the responsiveness of urban/residential demand is typically low, even at price levels generally in excess of those experienced in Britain. Significantly, more recent studies, which have used more sophisticated estimation techniques, have reported generally lower elasticities than those which emerged from most of the earlier, rather crude, cross-sectional analyses.

Except in those parts of Britain where garden watering is a significant component of demand, it is extremely likely, based on overseas experience, that urban demand elasticities of under - 0.2 and possibly under -0.1 will apply when consumers have metered supplies. This suggests that pricing will be a very blunt demand management tool in a post-metering situation, at least over the short term. Brooks et al (1990) and others have suggested that at higher price levels even internal residential demand will respond to price in that the design and adoption of more efficient water using technologies will occur. Such technologies act to shift the demand curves, and consumers, over the longer term, step between demand curves rather than move along one curve in response to price rises (see Figure 4.3). There is some evidence supporting this scenario, in that studies which have modelled demand over both the short and long runs have established higher long-run elasticities (Carver and Boland 1980). Evaluations of garden water use in Australia have also demonstrated that major demand shifts occur when consumers move to 'native' plant species, but how for this change was fashion rather than a price response, is unknown.

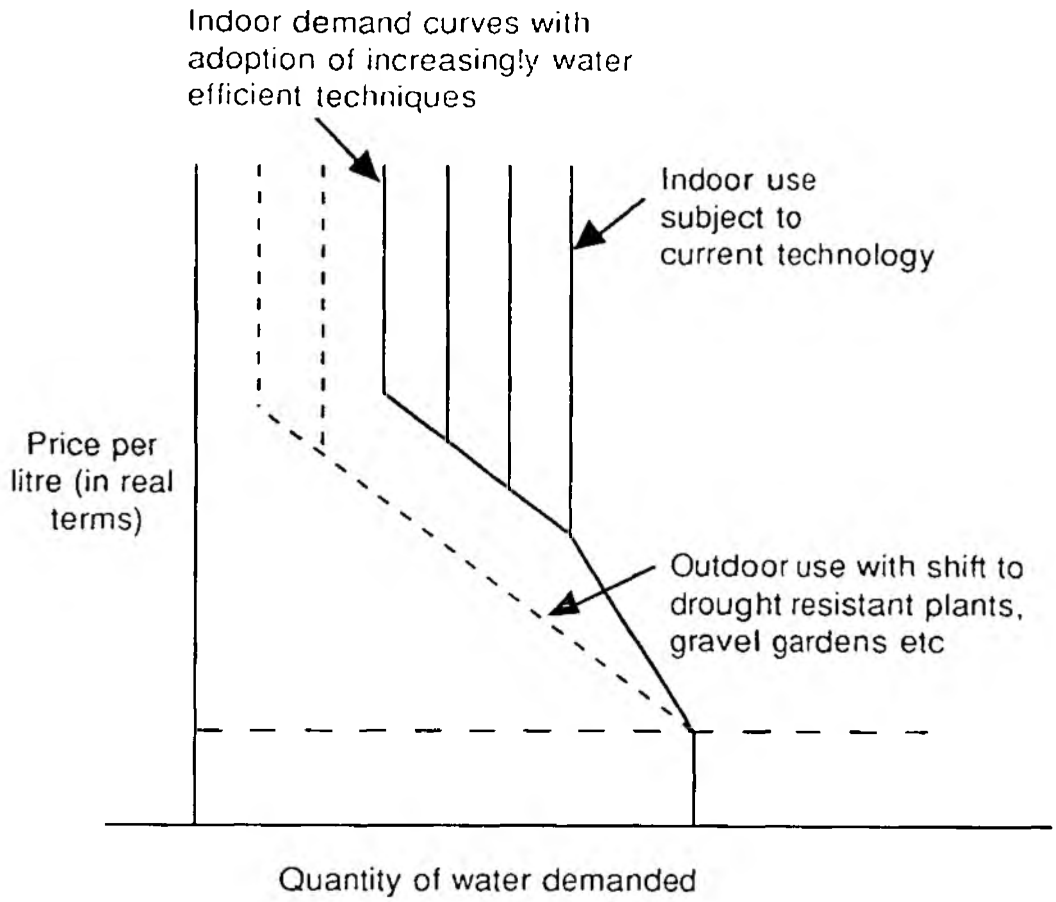


Figure 4.3 Conceptual Demand Curve for the Residential Sector Over Time, adapted from Brooks *et al* (1990).

4.8.3 The Initial Impact of Metering

All the above studies of elasticity are dealing with situations where charging by measure is a well established fact of life. Also relevant is overseas evidence of the impact of introducing metering and payment by measure for the first time. Metering and unit charging clearly involves a very high once and for all initial price rise from zero to some positive value; the size of the price rise will amongst other things determine the initial effect on demand.

There is now a considerable body of evidence on the initial demand effect; a selection of this evidence is presented in Table 4.5.

TABLE 4.5 PART A: TIME SERIES STUDIES					
LOCATION	TIME PERIOD	CONSUMPTION PRE METERING	CONSUMPTION POST METERING	% REDUCTION	SOURCE AND COMMENTS
KINGSTON N.Y	1957-1963	5.47 MGD	4.08MGD	27%	CLOONAN (1964). % PROPERTIES METERED INCREASED FROM 14-98%)
ELIZABETH CITY, NC	1931	1.8 MGD	0.3MGD	83%	AMERICAN CITY (1946)
ZANESVILLE, OHIO	1958-61	632 Mld	492 Mld	22%	AMERICAN CITY 1965
BOSTON, MASS	1907-1915	102 MGD	72 MGD	29%	WARFORD (1967). % PROPERTIES METERED INCREASED FORM 20-70%
BOULDER, COLORADO	1955-68	7.7 G PER HOUSEHOLD PER MONTH	4.9G PER HOUSEHOLD PER MONTH	36% AVERAGE INTERNAL HOUSEHOLD USE	HANKE?????
SYDNEY, AUSTRALIA	1880	173 lhd	159lhd	8%	SHIPMAN (1978)
KINGSTON, N.Y	1957-63	20.7Mld	15.4Mld	26%	HERRINGTON AND TATE (1971)
DENVER, US.	1957	691 lhd	639 lhd	7%	SHIPMAN (1978)
PHILADELPHIA, USA	1955-62	2562lpd	1408lpd	45%	HERRINGTON AND TATA (1971)
FREDERICIA, DENMARK (109 ONE FAMILY HOUSES	1971 (WINTER) -72 (SUMMER)	1010 lpd 1470 lpd	460 lpd 830 lpd	54% 44%	LONDON (1984)
MOSS CITY, NORWAY	1979-83	446lhd (AVERAGE DAY)	246 lhd	45%	HERRINGTON (1987)
		16.2 Mld (PEAK DAY)	8.6 Mld	47%	
TOOWOOMBA, QUEENSLAND AUSTRALIA	1978	450 lhd(AVERAGE DAY)	350lhd	22%	BROAD (1984)
		864 lhd (PEAK DAY)	680 lhd	21%	
		680 lhd (PEAK MONTH)	399 lhd	41%	
HUNTER DISTRICT, AUSTRALIA	1982	290 lhd (AVERAGE DAY)	199 lhd	31%	BROAD (1986)
PERTH, AUSTRALIA	1964-69	61lhd	27 lhd	56%	VERMERSCH (1974)

PART B:CROSS SECTIONAL STUDIES			
LOCATION	COMPARISON	SAVING	SOURCE
U.S	10 METERED AND 8 FLAT RATE AREAS	34% INTERNAL SPRINKLING 58% PEAK DAY	UNAWEAVER, GEYER AND WOLFF (1960)
HOLLAND	4 100% METERED TOWNS; 3 UNMETERED	53 G.P.D 88 G.P.D	WARFORD (1967)
UNITED STATES	ALL MUNICIPALITIES OVER 5,000 PEOPLE	25%	PORGES (1954)
GOTHENBURG, SWEDEN	SINGLE HOUSES METERED WITH APARTMENTS UNMETERED	33%	SHIPMAN (1978)
COPENHAGEN, DENMARK	63 METERED SYSTEMS AND 148 NON- OR PART- METERED SYSTEMS	20%	SHIPMAN (1978)
TORONTO, CANADA	?	WINTER 32% SUMMER 16% ALL YEAR 25%	UNITED NATIONS (1980)
TOWNS IN ALBERTA, CANADA	PER CAPITA CONSUMPTION IN TOWNS: METERED TOWNS, AND UNMETERED TOWNS	37%	GYSI (1981)
DENVER, U.S.A.	METERED AND UNMETERED HOUSEHOLDS	19%	ENVIRONMENTAL DEFENSE FUND (1980)

Table 4.5 The Initial Impact of Metering: Overseas Evidence.

Two methods of assessing the impact have been employed; first, time trend analyses measuring pre and post metering consumption trends in individual towns and second, cross-sectional studies comparing consumption in metered and un-metered towns. The former method gives more reliable results but has the disadvantage of being locationally specific. As expected the reported savings achieved by metering do vary quite markedly. In part this arises because the studies are not measuring exactly the same thing; many include reductions in 'unaccounted for' water in the savings, whilst others are reporting the real demand effect on household consumption. However, from the best available evidence the expectation would be that average domestic consumption would fall by at least 10% to which must be added the extra savings from reduced pipeline leakage. However, peak summer use could be more significantly reduced; taking climatic conditions into account savings in peak consumption (day and month) of between 25% and 30% would be the best estimate for the UK.

In all known cases, the introduction of meters effects a permanent lowering of the demand trend line. Clearly post metering consumption levels will at some time reach those experienced pre-metering but it is spurious to claim that the metering effect is therefore only temporary; account has obviously to be taken of the demand increases which would have occurred over the relevant time period. Where studies, such as that by Broad 1986, have analysed the pre-metering trend line, and the divergence of post-metering demands from this trend, then it appears that not all the savings occur immediately after metering; further adjustments occur in years 2 and 3 as consumers adjust their usage by purchasing new more water efficient consumer durables and water fittings.

4.8.4 Commercial and Industrial Demand Elasticities

Table 4.6 summarizes the much more restricted evidence on the price/demand relationships for the industrial and commercial users of mains water. As was the case for the residential sector, the overall conclusion from these studies is that commercial and industrial users are relatively unresponsive to price at the charge levels encountered in the study areas. In line with expectations the long run elasticity is significantly greater than that encountered in the short term. Although the reported evidence gives some insights into the possible reactions of industrial and commercial users to price changes, care has to be taken in interpreting and generalising the information. The studies employ different water price measures - some take the marginal price, others the average, some include the price of waste-water disposal. The prevalence of declining block tariffs in the United States and Canada also affects the results, and differences in industry mix and technology employed may mean that the reported elasticities are not valid for Britain.

LOCATION	ELASTICITY	USER CATEGORY	SOURCE
NETHERLANDS (ROTTERDAM)	NIL	INDUSTRIAL	ROTTERDAM WATER AUTHORITY (1976)
U.S. (COLUMBUS, OHIO)	-0.44 (BUT NOT SIGNIFICANT AT THE 5% LEVEL)	INDUSTRIAL	SCHNEIDER AND WHITLATCH (1991)
CANADA (BRITISH COLUMBIA)	-0.92 LONG RUN -0.24 SHORT RUN -0.12 TO -0.54	COMMERCIAL AND INDUSTRIAL	RENZETTI (1988)
U.S	-0.438 -0.14	INDUSTRIAL COMMERCIAL	WILLIAMS AND SUH (1986)
U.S.	-0.80	INDUSTRIAL	RENSHAW (1956)
U.S	-0.35 TO -0.89	INDUSTRIAL	DEROOY (1973)
U.S	-0.73	INDUSTRIAL	ELLIOTT (1973)
U.S	-0.11 -1.33	COMMERCIAL-MOTELS COMMERCIAL - DEPARTMENT STORES	LYNNE ET AL (1978)
U.S (COLUMBUS OHIO)	-0.78 LONG RUN -0.49 SHORT RUN -0.96 LONG RUN -0.37 SHORT RUN	GOVERNMENT BUILDINGS. SCHOOLS	SCHNEIDER AND WHITLATCH (1991)

Table 4.6 Price Elasticities for Commercial and Industrial Mains Water Use

All the studies referred to in Table 4.6 are concerned with aggregate group demand relationships; there are in addition a small number of investigations which have considered the demand schedules of individual plants or particular types of industry (Granstrom et al 1969, Ethridge 1970, Ridge 1972). From this work there are suggestions that the responsiveness of industrial demand to utility prices varies with water end use. While price appears to affect the demand for cooling water and boiler feed, it was more difficult to establish significant price/demand relationships for water used for in plant 'domestic' purposes and for processing. This may help explain why for some industry groups demand appears unrelated to price.

4.8.5 Deriving Values in Use

Overwhelmingly, the literature on urban demands has been concerned with elasticity measurements at specific price points, rather than with value in use estimation. Few attempts are known to have been made to develop generalised demand curves from the evidence; indeed the problems involved in doing so are formidable. The difficulties involved in isolating price from all the other variables influencing demand and in addition there is uncertainty about the way the price and quantity data have been defined (Foster and Beattie 1979; Martin and Thomas 1986).

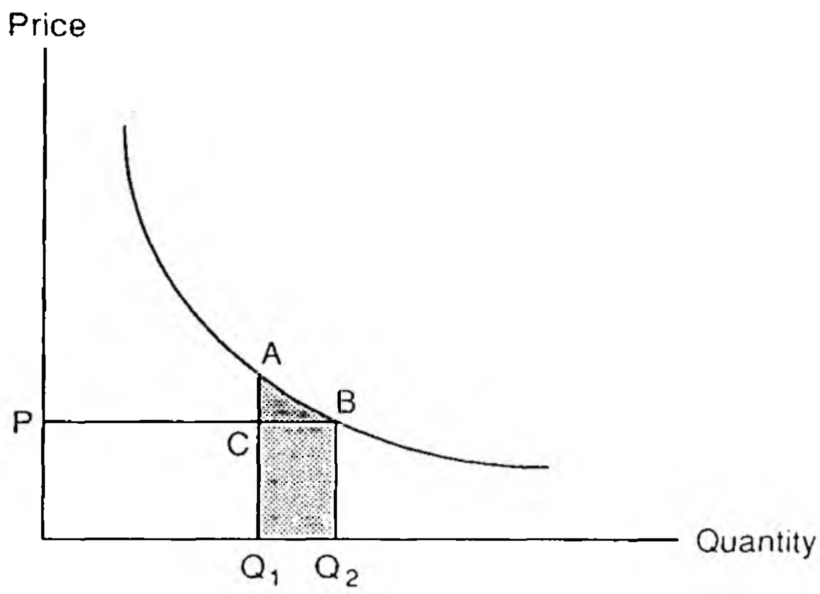


Figure 4.4 Deriving Urban Value in Use (from Gibbons 1986).

If demand curves are known (and the assumption is made that willingness to pay is a measure of the value of a particular unit of water to the consumer) then the area under the demand curve (ABQ2 01 on Figure 4.4) is the value in use of the supply unit. However, values derived in this way cannot be compared directly with any values established for abstracted water or in-situ river uses simply because the urban supplies have been treated, transported and delivered at pressure to users. In other words the demand curve measures the willingness to pay for potable supplies at the tap and not raw river water. Therefore, to obtain comparable figures it is necessary to subtract the relevant water undertaking costs per unit supply. If we make the assumption that the price charged for supply will reflect provision costs, then the imputed value of the raw abstraction water is the so-called consumer surplus (ABC, Figure 4.4).

Gibbons (1986) is the only known attempt to employ this methodology. She calculates value in use from the price elasticities and price levels reported in four demand studies (Danielson 1977, Grima 1972, Howe and Linaweaver 1967 and Young 1973); all prices were made comparable by converting to 1980 dollars using a GNP price index. Assuming that the reported price elasticity is constant over the segment of the demand curve under consideration, estimates were made for four different absolute reductions in consumption from the average household consumption in summer and winter (25, 50, 100 and 200 cubic feet). The results are shown in Table 4.7 and Figure 4.5. While there are problems with the methodology and the data employed and while the results cannot be generalised to Britain, the work does demonstrate that the marginal values in use of the first tranche of supply reduction are relatively low, but they escalate for internal use as greater supply restrictions are applied. Gibbons argues that some verification of his figures comes from the high prices achieved in the water markets of Western United States (ie where a tradeable right system is in operation). Water undertakers were paying the equivalent of $300 per acre feet (1981 prices).

LOCALITY AND DATE	SEASON	PRICE (1980 DOLLARS)	ELASTICITY	AVERAGE CONSUMPTION (CCF/HOUSEHOLD /MONTH)	1/4	1/2	1	2	10% REDUCTION
TUSCON, ARIZ. 1979	WINTER	0.72	-0.23	9.44	19	40	89	225	82
	SUMMER	0.83	-0.70	16.43	4	8	17	35	28
RALEIGH, N.C 1973	WINTER	1.27	-0.305	7.82	30	64	142	358	105
	SUMMER	1.23	-1.380	8.81	6	11	24	-	21
TORONTO, ONT. 1967	WINTER	0.79	-0.75	5.30	11	23	51	124	25
	SUMMER	0.79	-1.07	6.55	6	13	27	-	17

Table 4.7 Marginal Values for Residential Water Demand. Source: Gibbons (1986).

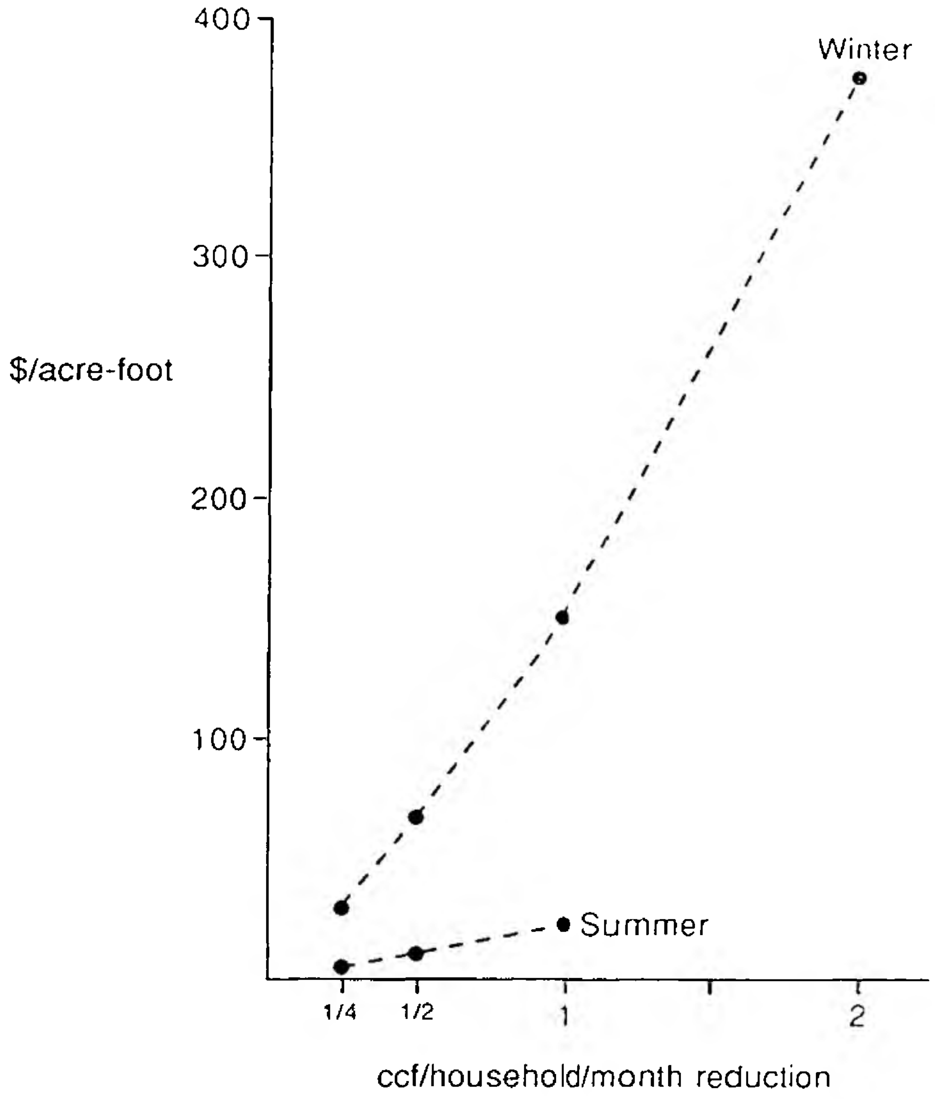


Figure 4.5 Marginal Water Values for Raleigh, North Carolina. (Gibbons 1986)

4.9 Urban Price/Demand Relationships:Evidence from Britain

4.9.1 Domestic Demand Elasticities

Until the current water meter trials, the only evidence on demand/price relationships for domestic consumers comes from Malvern, where metering has been practised since 1872 (Rees 1973). This now obviously dated work calculated that at the average price charged during the study period the elasticity of demand for all year round consumption was -0.11, increasing to -0.17 at the highest real unit price. As expected the elasticities for summer consumption were rather higher at -0.14 (average price) and -0.21 (highest real price). At present day prices the Malvern charges would be £1.02 (1991) (average) and £1.60 (highest) per 1000 gallons. The all year round elasticities were not significantly different from many of those established in the United States and Canada for internal domestic usage at similar price levels. However, not unexpectedly, summer demand was much less responsive to price in Malvern than it was in countries where garden watering and air-conditioning are larger components of demand.

4.9.2 The Impact of Domestic Water Metering

Four sources of evidence are available on the likely impact of the introduction of metering. First, the Malvern study referred to above concluded, after comparing consumption levels in Malvern with those encountered elsewhere in Britain, that a decrease of between 20% and 25% was the best estimate for the initial demand effect. This decrease would include both real consumption reductions and decreased pipeline leakage losses. Second, the Fylde metering experiment, involving 291 properties, suggested that an 11% fall in actual domestic demand would occur (Jenking 1973), a figure broadly confirmed by the third source, a comparative study of Malvern households and those in a metered (but uncharged) trial group of properties in Mansfield (Thackray, Cocker and Archibald, 1978).

	CHANGE %	TARIFF
BRISTOL	+2	FLAT RATE
EAST WORCS.	-19	SEASONAL
LEE VALLEY	-13	PEAK RATE
MID SOUTHERN	-3	FLAT RATE
NORTHUMBRIAN	-11	DECLINING
RICKMANSWORTH	*	FLAT RATE
SOUTHERN	-16	SEASONAL
THAMES	(-24)	RISING
WESSEX (TURLIN MOOR)	-30	FLAT RATE
WESSEX (BROADSTONE)	-15	PEAK RATE
YORKSHIRE	*	RISING
AVERAGE	-13	

Table 4.8 Analysis of Demand at the Small Scale Trial Sites. (Binnie 1992).

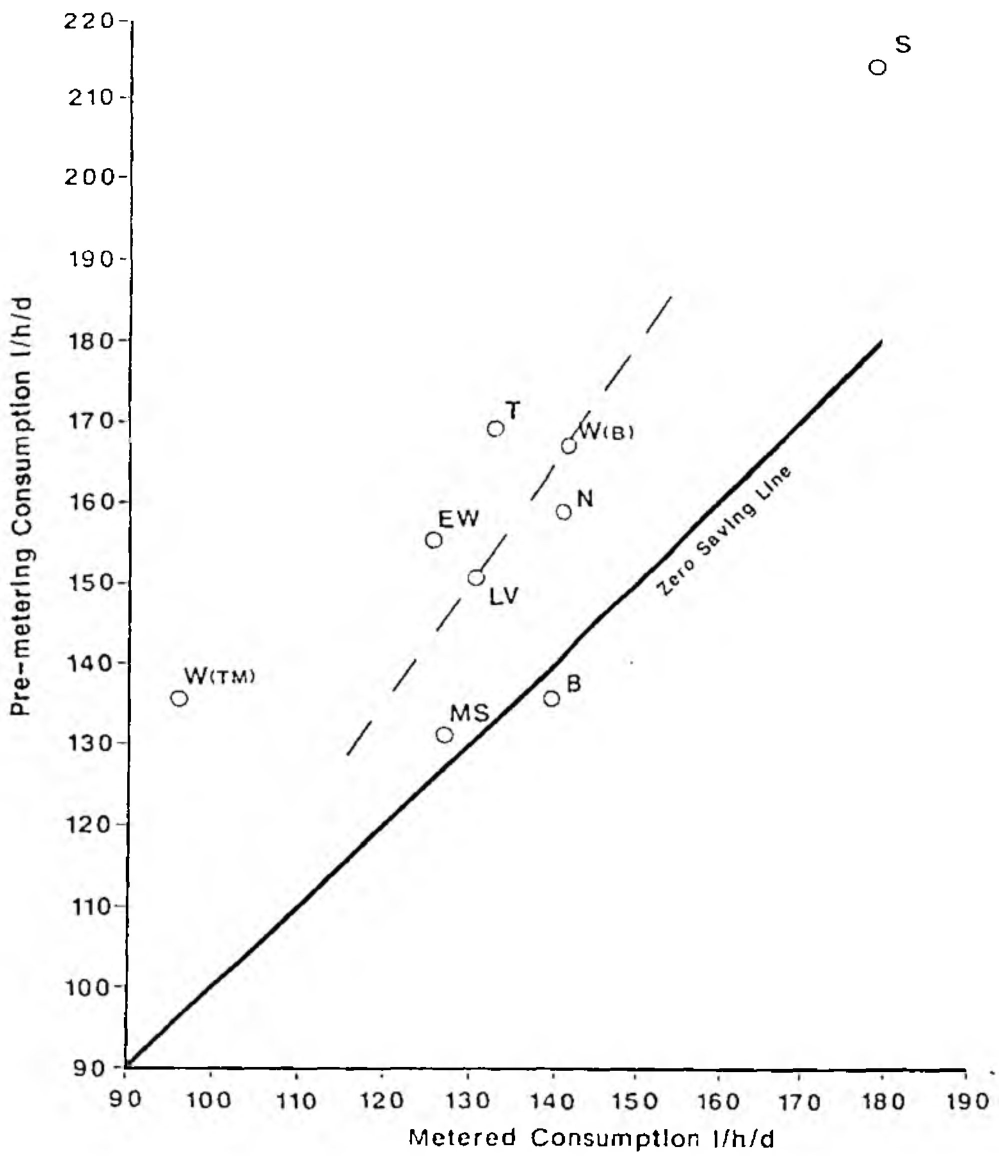


Figure 4.6 Comparison of Pre and Post Metering Water Consumption. (Binnie 1992).

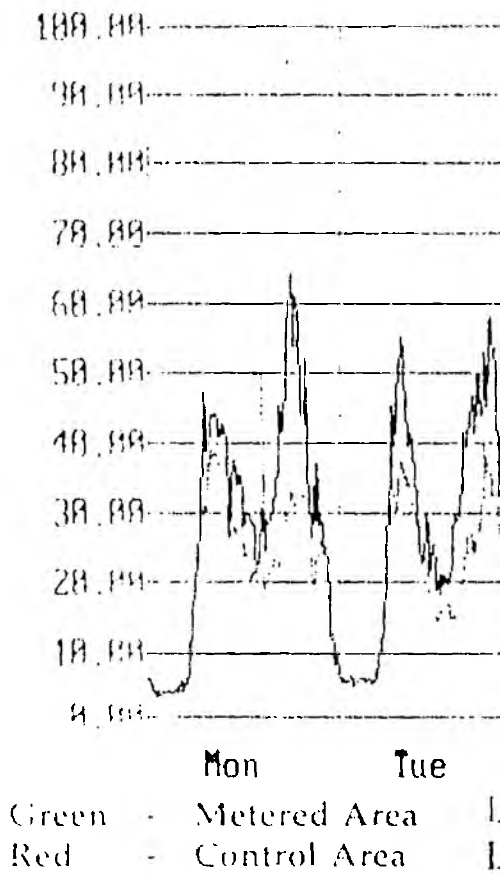


Figure 4.7 Consumption of Water in Summer Peak Period.

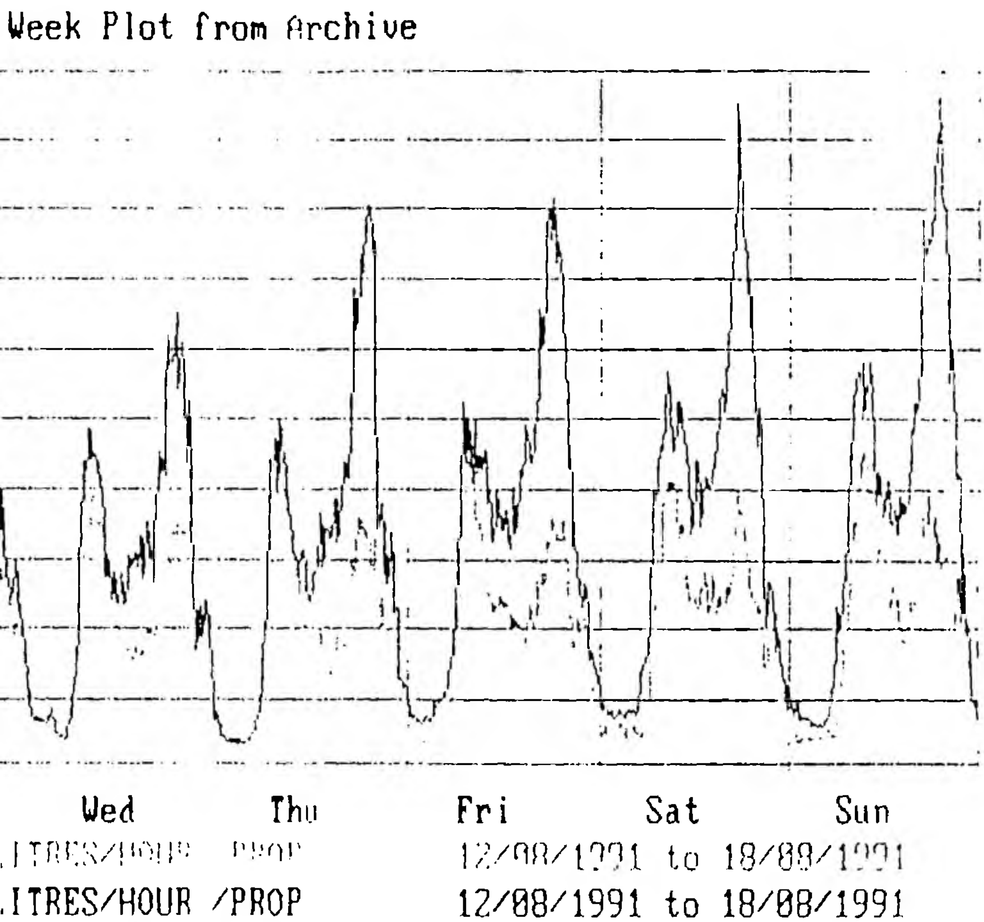

Week Plot from Archive
Wed
Thu
Fri
Sat
Sun
.ITRES/HOUR /PROP
12/08/1991 to 18/08/1991

Figure 9

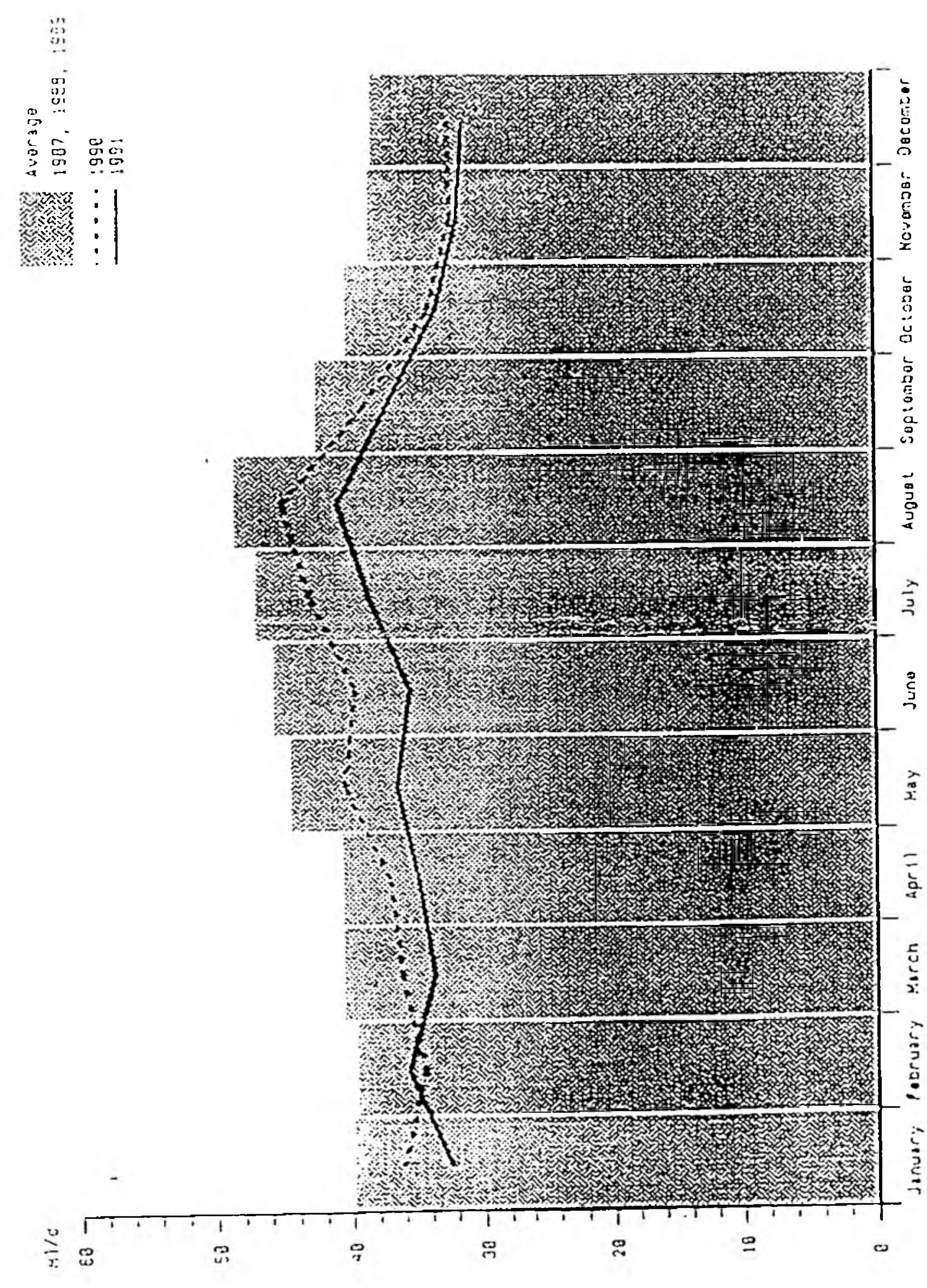


Figure 4.8 Water Taken into Supply.

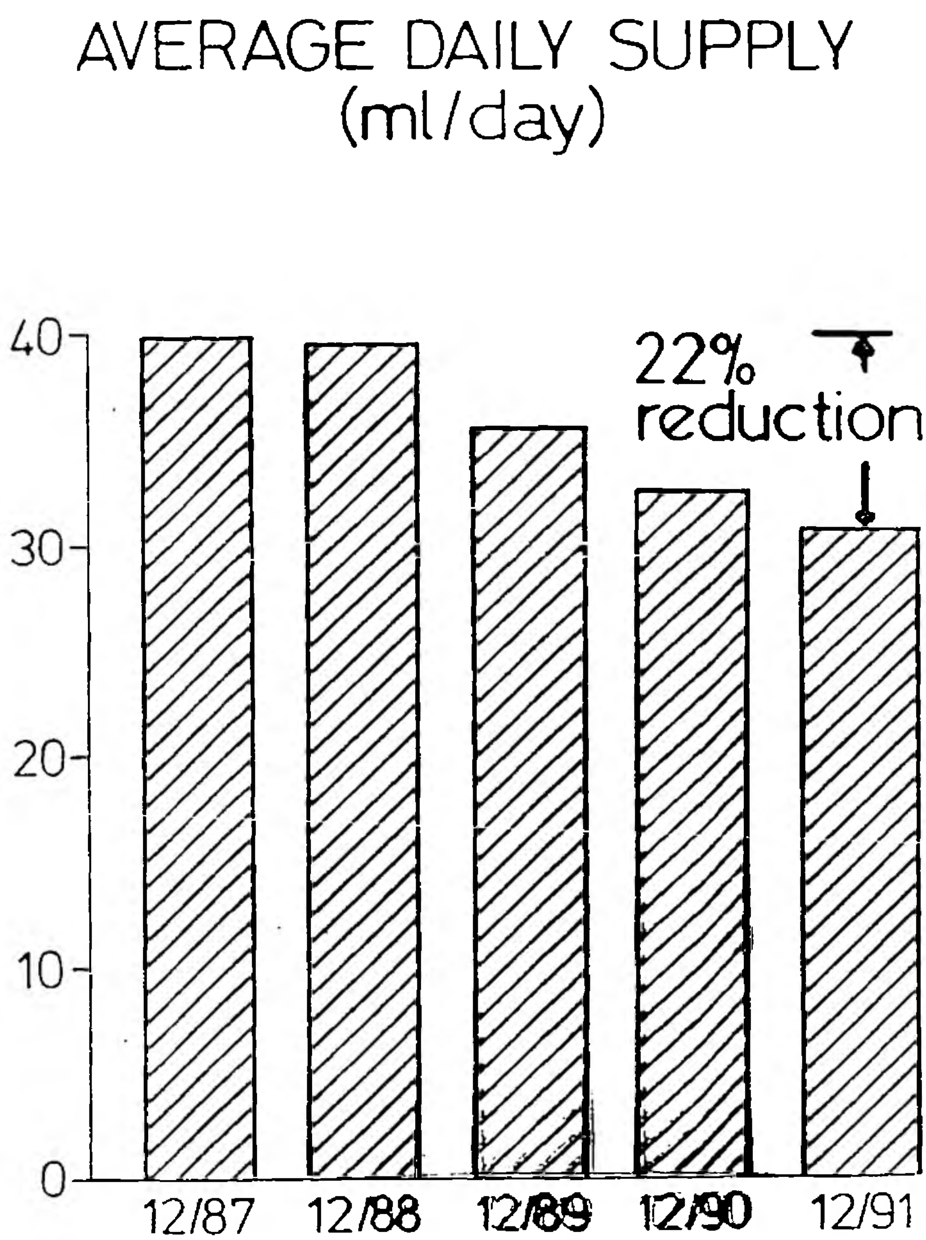


Figure 4.9 Average Daily Supply.

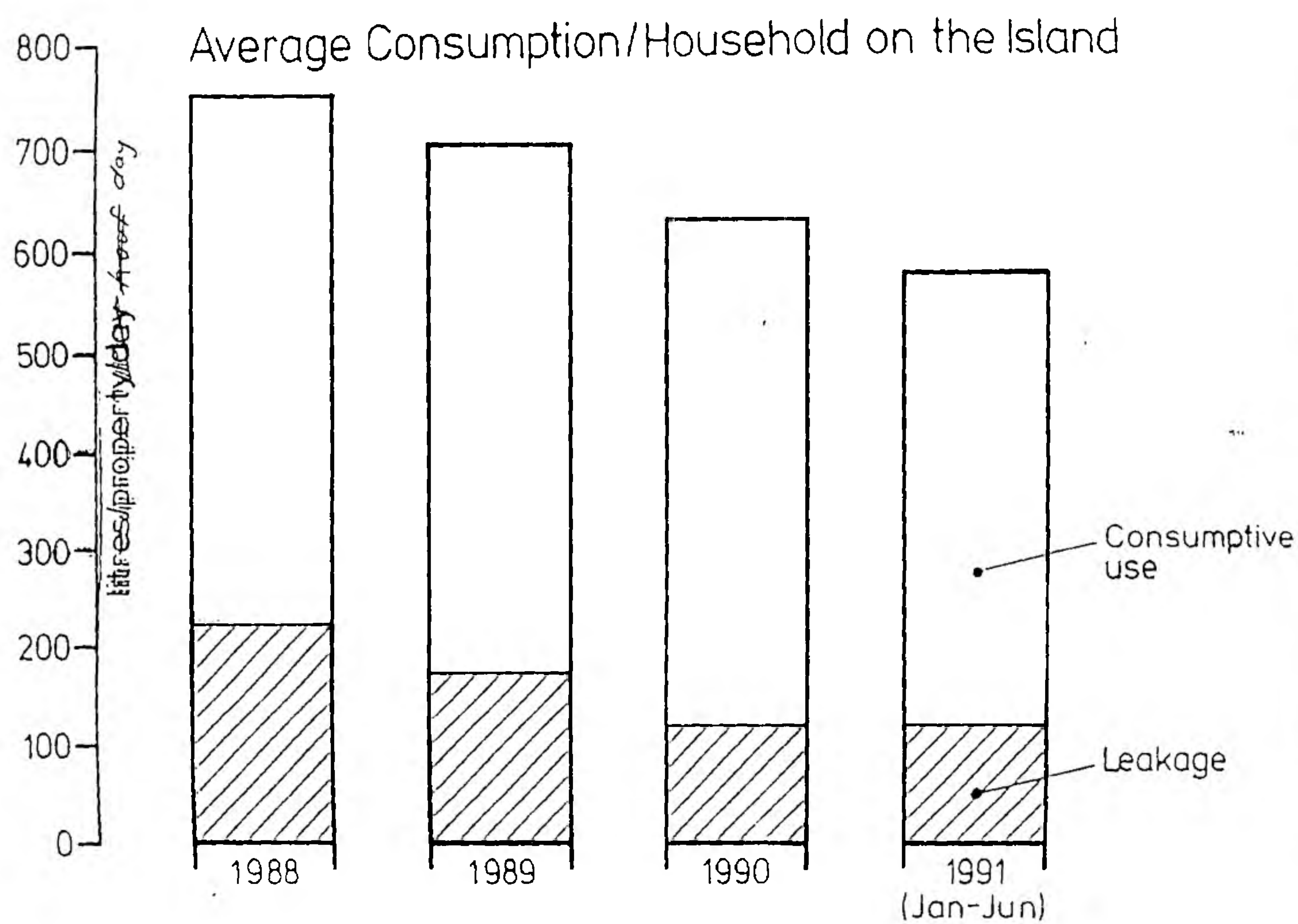


Figure 4.10 Average Household Consumption.

Finally, but of most importance, data is now emerging from the Water Metering Trials (National Metering Trials 2nd Interim Report 1991, 3rd Interim Report 1992). From the small scale trial areas, the average first year consumption drop was approximately 10%, which increased to 13% in the subsequent year. As the small area trials were designed to test the impact of a range of tariff structures, it is not surprising that the reductions in consumption have varied considerably between the trial areas (Table 4.8). Despite the Wessex (Turlin Moor) result (where there is doubt over the figure) there is some evidence that the highest reductions are experienced for increasing block and seasonal tariffs. Binnie (1992) has crudely calculated what these consumption reductions could imply for the demand trends, by comparing the metered consumptions with pre-metering levels (Figure 4.6). He concludes that the higher the pre-metered consumption, the greater the absolute benefit from metering. Importantly, the trials appear to be showing that metering has a greater impact on summer consumption than it does on average demand, and that it significantly cuts 'needle' peaks (peak hours), Binnie 1992 (Figure 4.7).

In these small trial areas all the reported reductions are in actual consumptions; however, study of the large scale Isle of Wight trial provides evidence on the effect of metering on the losses through pipeline leakage.

Recently released evidence shows that water taken into supply has markedly fallen as meters were introduced (Figures 4.8 and 4.9). A reduction of 22% in average daily supply appears to be indicated between 1988 and 1991, although this ignores the possibility that without metering demand would have risen above 1988 levels at between 1-2% pa. As Figure 4.10 shows both reduced consumption and reduced leakage contribute to the falls in per household supply. The Isle of Wight data supports Binnie's view that metering cuts the needle peaks.

Although further work on the trial data is still required, the results appear to be consistent with the earlier UK studies and with overseas evidence after allowance is made for varying climatic and consumer characteristics.

4.9.3 Industrial Demands for Mains Water

Only five known, publicly available, studies of industrial demand for mains water have been conducted in Britain. Three of these, Warford (1966), Herrington (1972) and Herrington (1982), are aggregate analyses and suffer from the problem of isolating the impact of price from all other variables affecting the demand for mains water. Warford, in a cross-sectional study, could find no statistically significant differences in the quantity of water supplied by different water undertakings and the prices charged. Herrington (1972), employing a multiple regression model to explain variations between regions in industrial consumption, did establish a significant price demand relationship [the price parameter used was the average income derived from each 1000 gallons of metered supply], with elasticities of -1.16 for England and Wales and -1.58 for England alone. However, in a later time trend analysis a much lower -0.3 elasticity was reported (Herrington, 1982). This last figure was supported by Thackray and Archibald (1981) in their study of the water saving investments made by firms within the Severn-Trent area.From overseas work it seems highly likely that the responsiveness of industry to metered water price charges will vary between industry groups. The only known evidence on such variations in Britain comes from Rees (1969) (Table 4.9); this data is, however, over 25 years old and was derived from very small samples of firms within each industry group. It would be extremely unwise to assume that the figures have any current relevance. As part of the field investigations for this study, attempts were made to use price to explain the differences in mains water consumption by the surveyed firms, however, no significant relationships could be established.

INDUSTRY GROUP	ELASTICITY	PRICE
CHEMICAL	-0.958 -1.00	£2.20 £2.40
FOOD	-3.28 -6.71	£1.70 £3.50
DRINK	-4.1	£2.30
PAPER AND PAPER PRODUCTS	-1.44 -1.95 -2.88	£1.70 £2.30 £3.40
NON METALLIC MINERALS	-2.5	£2.16
PLASTICS AND RUBBER	NO SIGNIFICANT RELATIONSHIP	
METAL PRODUCTS	NO SIGNIFICANT RELATIONSHIP	
MECHANICAL AND PRECISION ENGINEERING	NO SIGNIFICANT RELATIONSHIP	
OTHER FIRMS	NO SIGNIFICANT RELATIONSHIP	

Table 4.9 Price Elasticity Measures for Industrial Consumers in South-East England.

4.10 Conclusions

There is no one value in use of abstracted water for the industrial sector; it varies enormously between and within industry groups. Use value depends on the specifics of the manufacturing process and the purposes for which water is employed; it is also dependent on supply quality but the significance of quality varies with process, water-end use and the already installed treatment equipment within individual firms. All the available evidence suggests that in the short run the response of industrial abstraction to price will be slight. Water costs are a minimal element in total cost structures and choices about water use are secondary to decisions on process technology, material inputs, output mix and operating scale. For many firms water use decisions appear to be becoming increasingly influenced by waste water disposal costs.

However, in the longer term major changes in water using behaviour are possible, and abstraction charges could along with discharge pricing have a significant impact on the degree of recycling and thus on the demand for abstraction supplies. Overseas evidence, which is confirmed by the limited cost data obtained by our field survey, indicates that the cost per megalitre of moving from 'once through' water systems to recycling is low. This implies that the value in use of new raw abstracted water is also very low. Undoubtedly for many firms inplant recycling could be introduced at costs well below the expenditures which would be needed if the NRA were to enhance supplies. Judging by our very small sample of firms recycling costs vary between companies, but it would be surprising if they exceeded £15 per megalitre and for many companies would be significantly less than this.

The maximum marginal value in use can be estimated from the cost of mains water minus the additional treatment expenditure involved. A small group of firms in our sample were already considering switching away from mains supplies. The additional cost of treating abstracted water appears to be low, and enormous cost savings are possible. This could have major implications for the demand for abstracted supplies over time.

We found no evidence that companies were prepared to pay the NRA a reliability premium. In part this simply reflects the fact that reliability was not viewed as an issue. However, the apparently low cost of recycling suggests that the cost to companies of in-plant reliability increases would be significantly less than those incurred by the NRA.

As far as urban demands are concerned, the evidence strongly suggests that short run demand elasticity is slight and even over the longer term the responsiveness could be limited. However, some researchers have suggested that over time demand curve shifts occur in response to price as new technological developments take place. In a British context, the most significant impact on the demand for new abstraction water will be the potential introduction of domestic water metering. However, the subsequent effect of raw water price rises on end user consumption will critically depend on the way the water companies respond to the NRA's price signals in the design of their own tariffs.

5. 'IN SITU' VALUE IN USE

5.1. Introduction

The literature on the theory and methods of environmental evaluation is now very large and no attempt has been made to review this work here (see for example Pearce and Turner (1990). As discussed in Chapter 2 (2.5.3) valuations need ideally to include assessment of the use (or instrument value) of the environment and both its intrinsic and insurance (or risk avoidance) values.

Attention is focussed here on the studies which explicitly deal with water and are attempting only to measure use or instrument value; an emphasis is placed on work conducted in Britain. The chapter is divided into three basic sections - recreation and amenity uses, waste disposal and fish farming, (it is of course, recognised that this last is not strictly an in-situ use.) Except for a very small scale survey of fish farmers, no empirical work in in-situ uses was conducted as part of this project; the material is all from secondary sources.

5.2. Valuing Recreation and Amenity Benefits

5.2.1. Valuation Methods

The users of rivers or river banks for recreational purposes are a heterogeneous group, who are likely to place different values on the various attributes of the water environment. For example, those simply using the river bank as a pleasant place for a stroll or a picnic will be primarily concerned with the appearance of the water and its surroundings; others coming into physical contact with the water or fishing may place much higher values on the purity of the stream. In addition, the values accorded to different water environments by user groups may have more to do with the presence or absence of general amenities, such as car parks, restaurants and toilets, than with the attributes per se of the water body. Likewise, values may vary depending on the intensity of use and the types of other users frequenting a particular site. Those seeking solitude, for example, will devalue locations where other recreators are clustered, as will bird watchers and fishermen. Therefore the results of all studies which attempt to place values on water used for recreation and amenity purposes have to be interpreted with great care.

The basic techniques employed to place values on non-priced aspects of 'in-situ' water use are conceptually the same as those already discussed for agricultural and industrial abstractors, although the way they are applied will, of course, differ. Three methods have commonly been used - household production functions, hedonic prices and contingent valuation.

Household production function models are simply those which investigate changes in the consumption of commodities that are substitutes or complements for the environmental attribute being valued. They are, therefore, analogous to the 'next best alternative' approach used in the industrial abstraction case and the study of expenditure on storage employed for irrigation. By far the most widely used technique for estimating the value of water based recreation is to assume that the costs of travelling to a recreation site represent the willingness of users to pay for the experience and thus allows crude site valuations to be made. Although a plethora of travel cost studies have been conducted, very few have attempted to disaggregate the value of the water from the value of the site itself and fewer still have sought to establish unit water values (Young et al 1972). This last is hardly surprising given the procedure which has to be adopted to obtain such unit values, namely :-

a) establish total site value.

b) value the non water attributes of the site (ie., constructed facilities and general scenery)

c) estimate the value of the water per se by deducting (b) from (a).

d) divide the established water value by some appropriate measure of the total quantity of water, so notionally obtaining an average unit water value for recreation at the particular site.

The problems involved in using such an approach are clearly enormous, estimates of site values are in themselves subject to great uncertainty without the added difficulties of disaggregating these values into their component parts and of deciding what measure of water quantity to adopt. Although various travel cost models have been devised, most obtain site values in broadly the same way (Figure 5.1). They first construct a demand curve for recreation

at a specific site by estimating the travel costs incurred to reach the site. OB represents the costs of those travelling farthest, while OA would be the 'price' paid by someone living next to the site. Assuming that all the welfare from the recreational experience occurred at the site and none on the journey, all recreators paying less than OA would be obtaining a consumer welfare surplus, which is inferred to be the value of the recreational resource. If no fees are paid for access to the site the total area under the 'demand' curve is the surplus; however if an entry fee is levied (F) then the surplus value declines to the hatched triangle.

Hedonic methods of valuing river sites need no explanation here; they simply attempt to assess the differences in property values which arise from a river location and the more complex studies also explore any differences which arise because of variations in river quality, recreational facilities and so forth. All the

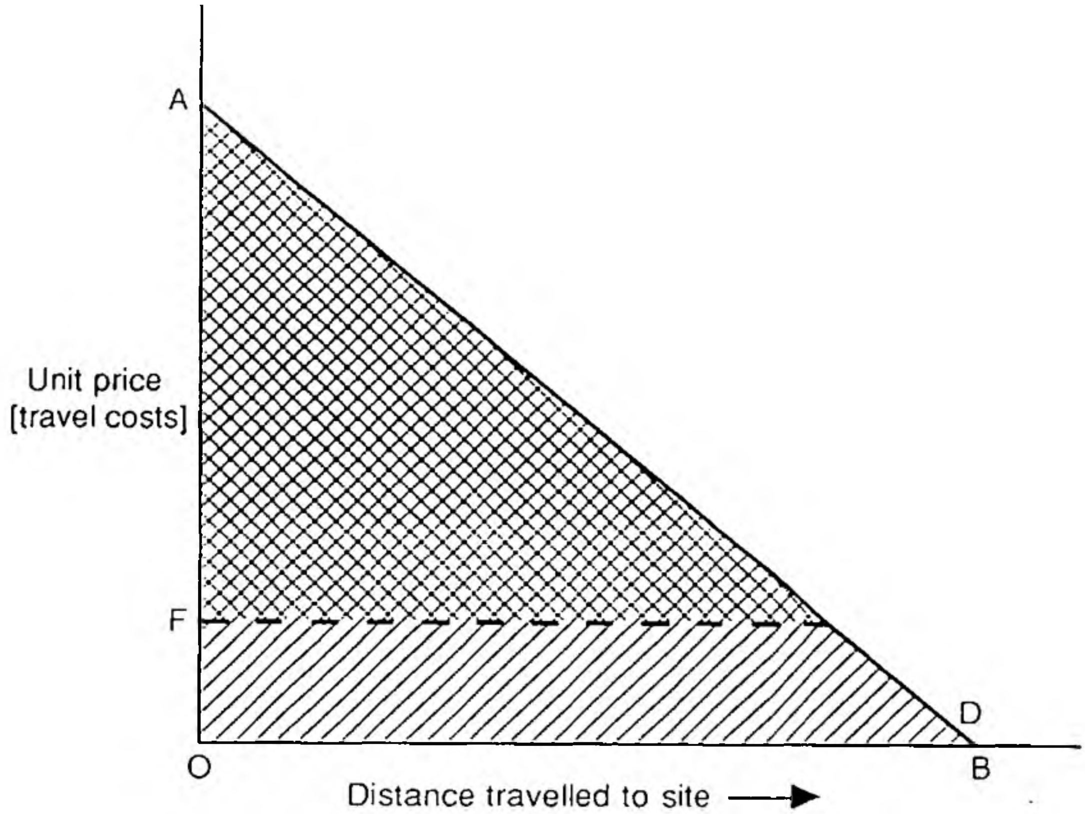


Figure 5.1 Travel Cost Model.

derived values critically depend on the ability of the researcher to isolate water-related attributes from all the other factors influencing house prices (such as proximity to work, shops, local schools and so forth).

The most commonly adopted contingent valuation technique is to survey users at specific sites and ask them how much they would be prepared to pay for an improvement in some site attributes, water quality for example. Alternatively, questions may be phrased in ways which elicit the amount of compensation required to compensate for an actual or hypothetical loss of an environmental good. Rather more sophisticated approaches using bidding games have also been adopted to illuminate the true willingness to pay in these hypothetical situations.

Clearly none of these valuation techniques are problem free. All have implementation difficulties and the results can depend as much on how the data were acquired, the specifics of the adopted model and on the biases within the techniques themselves than on the realities of value in use.

5.2.2. Transport Cost Models

Early studies of the 'in-situ' value of water focussed almost exclusively on recreational uses through transport cost modelling; many were concerned with reservoir sites rather than rivers simply because it was far easier to calculate visitor numbers and survey users in more spatially confined situations. The first transport cost study in Britain, by Smith and Kavanagh (1969) estimated the benefits of trout fishing at Graffham Water, Huntingdonshire, and was commissioned by the Water Resources Board. Early studies covered a range of recreational activities and were primarily concerned with estimating the total value of the water site rather than with establishing the marginal or average value of each visit; in other words their prime concern was not to establish a surrogate demand curve for the recreational experience. Interest in total values arose because such studies were typically made as part of larger exercises concerned with the calculation of the costs and benefits of reservoir construction programmes.

The first substantive piece of work which considered the recreational value of river water was conducted as part of a wider study considering alternative ways of meeting the water supply requirements of the East Midlands (Kavanagh and Gibson , 1971; Gibson, 1972). Transport cost models were employed to derive demand curves for fishing for various stretches of the river Trent, and aggregate consumer surplus estimates were made for each stretch. An unusual feature of this work was that it did not simply assume that each river stretch had the same underlying attributes, but attempted to relate the consumer surplus (or surrogate willingness to pay) at each stretch of river to various explanatory variables. Consumer surplus benefits in £s per mile were related to the numbers of anglers which could be accommodated per 100 yards, the quality and type of fishery, and a population distance cost index (to account for the different costs incurred in reaching the particular stretch of river). The angling benefits calculated varied enormously from zero for the river between Hardley-Harford-Great Heywood,to up to £6758 (1971 prices) per mile of river bank per year between Barton Ferry and Trent Bridge.

Although Kavanagh and Gibson did successfully apply the transport cost method to rivers, in general severe problems are encountered in its use for linear recreational features such as rivers and waterways. This arises because, typically, there are only a few major points of interest or sections of rivers where there are sufficient numbers of visitors from whom travel distance data (and thus the demand curves) can be obtained. If only 'honeypot' sites are valued then clearly a very partial idea of recreational values is obtained since experiences based on relative 'solitude' are ignored. It is not possible to overcome this problem by simply aggregating stretches of the river, because each section serves different hinterlands. In a very recent study by Willis and Garrod (1991) an attempt was made to address this issue by taking a large sample (3941 observations) to value the frequency of different types of recreational visitor to a large number of points along rivers (Weaver, Trent and Severn) and canals (Coventry, Grand Union, Trent and Mersey, Worcester and Birmingham, Gloucester and Sharpness). With a sample of this size it was then possible to use transport costs to value the consumer surplus for different kinds of 'in-situ' recreation along waterways. Although, as expected, the results varied somewhat from waterway to waterway, some plausible values were obtained. These ranged enormously per visit from a few pence for locals out for a stroll or walking the dog to over £3 for visitors to a specific water feature, such as the Anderton lift.

Lewis and Whitby (1972) employed the transport cost appoach in rather a different way to estimate the benefits derived from recreational visits to Derwent Reservior. Because of concerns about the statistical function employed to approximate the demand curve, they rejected the use of consumer surplus and instead calculated benefits from the price at which a profit maximising monopolist could maximize revenue. Using this approach, they estimated the benefit per visitor day at £1.30 for fishing, 55p for sailing and 35p for picnic/day trips (1971 prices). Price elasticities were also estimated ranging from -2.2 for fishing, -3.3 for day trips, and -1.6 for sailing. These are all relatively elastic and confirm the view that the volume of this type of recreation at a particular site is very much determined by the relative price of access and the number of alternative sites. It is expected that recreational uses which require highly specific site attributes will have lower elasticities.

Income elasticities of demand were also calculated by Lewis and Whitby,these were , +0.8 for fishing and +0.6 for day visiting, but -0.8 for sailing. The latter result is somewhat perverse and has also been encountered by other researchers (Smith, 1970). It can be explained by the fact that a person with low income may be much less likely to pay a membership fee for a sailing club than a person with high income. However, a low income person who does join will do so because he is sure of using the club facilities frequently; whereas the person with a higher income may be willing to pay the membership fee for just a few visits. Hence the income elasticity of demand for visits is negative; whereas the income elasticity of demand for membership is positive. Lewis and Whitby (1972) found support for this argument in their data: the separation of lower incomes led to a change in the sign of the income elasticity, although due to a small sample size the results were not highly statistically significant.

A vast number of transport cost studies have been undertaken in the United States; many are highly site specific and have no practical relevance to Britain. However, one group of investigations does warrant brief discussion. These relate not to the demand for recreation at individual sites but the demand for water-based recreational experiences as a whole and employ information from the US Census Surveys for participants in outdoor recreation. While price elasticities of demand for recreation at individual sites can be high, due to the availablity of substitute locations, as table 5.1 shows this is not true for water-based recreation as a whole. The aggregate elasticities were low, ranging from -0.11 to -0.40. The same census data sets have also been used to look at the demand for water recreation based on the income, age, education and sex of

WATER BASED	
FISHING	
VACATION	-0.24
WEEKEND TRIP	-0.27
DAY OUTING	-
CANOEING	
VACATION	-0.29
WEEKEND TRIP	-0.19
DAY OUTING	-0.16
SAILING	
VACATION	-0.25
WEEKEND TRIP	-0.11
DAY OUTING	-0.40
OTHER BOATING	
VACATION	-0.23
WEEKEND TRIP	-0.18
DAY OUTING	-
SWIMMING (NATURAL LOCATION)	
VACATION	-0.24
WEEKEND TRIP	-0.20
DAY OUTING	-
OTHER RECREATIONAL ACTIVITIES	
CARS	-1.2 TO -2.1
AIRLINE TRAVEL	-2.4
RADIO AND TV SETS	-1.2
NEWSPAPERS	-0.1

Table 5.1 Price Elasticities of Demand for Outdoor Water Based Activities in the U.S. Source Willis 1992.

participants. Interestingly, the income elasticities appear to be rather low, which suggests that as incomes rise a smaller proportion of income is devoted to water based recreation.While transport cost models have predominately been used to value the recreational experience itself, some work has been done using the same approach to evaluate the recreational losses incurred through river or lake pollution. For example, Loomis (1991) discusses fishing benefits lost due to accidental pollution spillages in rivers, while work on visitors to eight small lakes in south-east Wisconsin attempted to measure reductions in visitor trips generated by declines in lake water quality.

5.2.3. Hedonic Price Models

Hedonic studies have mainly concentrated on estimating the impact of negative externalities, such as aircraft and road traffic noise or air pollution, on property values, rather than estimating the impact of positive externalities such as water. However, households purchase residential property in proximity to rivers, canals, and lakes both to enjoy the view of this environmental amenity and also to gain recreational access to it (e.g. in terms of a right to moor a boat, or to avoid transport costs of gaining frequent access to a river).

A study of the value of countryside characteristics in the Forest of Dean area, including the rural areas of Gloucester, Hereford and Worcester revealed that certain characteristics had a highly significant impact on house prices, of which the presence of a river (mainly the Wye and the Severn) was one, adding 4.9 percent to the value of a house, ceteris paribus (Garrod and Willis, 1992). A subsequent study of the impact of canals on property prices in the Birmingham and London areas (Willis and Garrod, 1992) revealed that, holding all other variables at their mean levels, the waterside location of a property in London added a small premium to house prices. As well as being statistically significant, these results appear valid from the construct model and criterion validity of the model; in other words the model gave reasonable results when used to predict other market good values, such as the house price premium for a single garage, double garage, central heating, additional bedroom, additional bathroom, for which data was known.

There is no reason to suppose that the value of waterside location is similar in different housing market areas around the country: supply and demand conditions are likely to vary in space to some degree. In addition, the type of water course is also likely to have a differential impact on house prices. Rivers, being wider and more 'natural', might be expected to command a higher price premium than canals. Local environmental factors too might impinge on the price differential. The recent executive housing (£100,000 to £150,000 price range) development at St. Peter's Basin, Newcastle upon Tyne by Barratt, resulted in premiums of 10 percent for houses overlooking the Tyne and 15 percent for those which overlooked the Tyne and marina, compared to identical houses at the rear of the development which were overlooked by a scrapyard! But with a more pleasant (rural) environment at the rear, the differential would not have been so great.

5.2.4. Contingent Valuations

The vast majority of studies using this approach have been conducted in the United States and Canada (for reviews see Gibbons, 1986, Yardas et al 1982, Young et al 1972). While the results in themselves have little significance for Britain, two points are worth recording since they could have relevance for NRA stream management practices. First, recreation (active and passive) values in use appear to vary with water flow levels. The highest marginal values for fishing and river side recreation, for example, were found with low flows (0-50 cubic ft. per second). Moreover, recreational values (as measured by the number of days an individual is willing to visit a site) appear not to change until a 50%

reduction in flow from peak levels takes place; in other words the marginal value for high flow levels appears to be zero (Loomis and Ward 1985). Second, although considerable variations in value in use estimates have been made, values, particularly for fishing, appear to be relatively high - ranging from $19-$40 per acre foot (1970s prices) and from $3 to $54 per user day; the highest figures being derived for specialist fishing and waterfowl hunting. Enormous problems exist with the methods employed to derive these values, but they are of some interest since they are as high or higher than those achieved for some industrial abstraction purposes (see 4.2.2).

In Britain, the most recent, and by far the most comprehensive, study using contingent valuation techniques has been conducted by the Middlesex Flood Hazard Unit (Green et al 1990, Green and Tunstall 1991). The central concern of this work was to estimate the recreational benefits from improvements in water quality in British rivers. Visitors (873 observations) at twelve different sites and residents (621) living less than 2 kms from an accessible river were surveyed. Their willingness to pay for improved river quality was assessed (table 5.2) in terms of the perceived water quality being good enough to :

- support water birds
- support fish and different water plants
- be safe for children to paddle or swim

However, the authors have clearly demonstrated that their results, in common with all contingent valuations, suffer from the difficulties which people experience in articulating and assigning values. For example, the average willingness of visitors to pay for improved quality was very sensitive to the starting 'offer' made in the survey. So if 50p per month was the starting point (as the assumed value of the recreational experience with existing river quality levels) then the average willingness to pay for improvements was £1.41p. However, when the starting point was increased to £1 per month, the willingness to pay for improvements moved up to £2.01p; while expressing the starting values in £ per year produced startlingly different results, with a £6 per year start point yielding an apparent willingness to pay for improvements of £19.56.

GOOD ENOUGH	% WHO VISIT MORE OFTEN	WTP (PENCE)
FOR BIRDS	66	51
FOR FISH	80	60
TO SWIM	77	52

Table 5.2 Willingness to Pay for Water Quality Improvements in British Rivers.

Such problems are inherent in the contingent valuation technique. In an attempt to evaluate the extent to which results can be biased by the method used to elicit willingness to pay estimates, a number of studies have employed several estimation techniques at the same time. One such example is the study by Desvousges, Smith and McGivney (1983) which investigated the benefits from water quality changes in the Monongahela River in Pennsylvania. They considered three scenarios :

- a decline in water quality resulting in a complete loss of all recreational activity.

- an increase in water quality from from boatable to fishable.

- an increase in water quality from boatable to swimmable.

For each of these scenarios four different methods of contingent valuation were used and in addition, a transport cost approach was employed for the two improvement scenarios. As table 5.3 clearly demonstrates very different valuations resulted, particularly when iterative bidding with a low start bid was employed.

	LOSS OF USE	WQ BOATABLE TO FISHABLE	WQ BOATABLE TO SWIMMABLE
DIRECT QUESTION	6.57	7.06	13.61
PAYMENT CARD	6.20	9.72	15.92
ITERATIVE BIDDING (START $25)	2.16	1.38	3.12
ITERATIVE BIDDING (START $125)	12.08	6.77	13.43
TRAVEL COST	-	7.01	14.71

Table 5.3 WTP for Changes in Water Quality in the Mononqola River ($ 1981 prices) Use Values.

5.2.5. Conclusions

Although a considerable amount of work has been undertaken, and is still being undertaken, to improve environmental valuation techniques, it is still true to say that our knowledge of 'in-situ' water values is rudimentary. Certainly, it is not sufficiently advanced to be used by the NRA for water resource planning purposes.

5.3 Value in Use for Waste Assimilation

5.3.1 Alternative Value in Use Measures

Incentive based systems of charging for waste disposals to rivers are a rarity [Environmental Resources Ltd 1990; Royal Commission on Environmental Pollution, 1992]. A limited amount of evidence has emerged from studies of such systems on the way firms respond to charges but they provide no basis for the construction of demand curves for the waste assimilative capacity of streams. Although further insights into the responsiveness of industry to pollution pricing can also be obtained from investigations of trade effluent charges (for discharges to sewers) these once again provide a poor basis for demand curve estimation.

Therefore, the value in use of water for waste assimilation has to be measured indirectly using surrogate estimation methods.

There are four potential ways of approaching the problem of getting some idea of the value of the rivers as diluters and bio-degraders of wastes. First, where stream quality standards have been established, one possible measure is the costs involved in releasing water from storage to augment flows (or alternatively the costs of reduced upstream abstraction) in order to allow the required standard to be met. Clearly this approach is only appropriate for those pollutants that are biodegradable or, where if not degradable, where dilution can achieve acceptable concentrations. Considered in this way, value in use for any set disposal will vary considerably over both space and time. The <u>amount</u> of flow augmentation required will alter with natural stream flows, upstream abstraction levels and the plethora of variables (including the presence of other sources of pollution) which affect available oxygen. In addition the <u>cost</u> of augmentation flows will vary with the supply capacity situation, being negligible at times or in areas where excess capacity exists and being extremely high where the construction of new storage capacity is needed to provide the flow augmentation. [These two states represent the possible short and long run values in use of the river for waste assimilation.]

Calculations based on storage capacity costs are certainly possible, but they would be highly stream, time and pollutant specific; each disposal could be associated with a unique set of waste assimilation values in use. However, thinking about value in use in this way does bring out three important issues which could be addressed by the NRA when, and if, the current cost recovery charging scheme for direct discharges is reviewed. First, the value in use of the river for waste assimilation is highly seasonal, not only because of natural stream flow and temperature variations, but also because, in some catchments at least, abstraction demand has a summer peak and the available release capacity in multipurpose storages will normally be small. There is then, a considerable economic justification for including a peak summer use element in any full cost related discharge pricing system. Second, but a related point, waste disposal and abstraction are obviously direct competitors for available natural river flow and flow augmentation storage facilities; there is then no economic rationale for charging one group for the water on a marginal cost of capacity basis (see Chapter 2) and, in effect, giving it away to the other group. Both should be subject to the same marginal supply costs for 'consumed units' (and flow augmentation storage costs can establish these) or resource allocations will be distorted. Third, when dischargers are charged on the basis of flow augmentation expenditure, the NRA will have better information on which to base decisions on the true demand for additional storage capacity to support 'in situ' use.

A second method of placing a value on the water employed to dilute or degrade wastes is to estimate the downstream damage costs avoided by different flow levels. Once again the calculated values in use are spatially, temporally and pollutant specific. While some of the damage avoidance benefits are, in principle at least relatively simple to estimate (eg treatment costs avoided) others which involve aesthetic, recreational or wildlife damage present more intractable problems. It would seem likely that the first approach (flow augmentation storage costs) is a much more practicable proposition, at least until our techniques of environmental evaluation are improved (Johansson 1987).

The third and fourth methods are closely related; one is based on the costs of preventing the creation of waste units, while the other considers the costs of treating the waste after generation but before discharge to the rivers. Prevention costs, in the case of manufacturing industry, could include changes to industrial processes, material inputs or product types, the reduction of output, including factory closure, and the installation of recycling and by-product reclamation systems. For farming they could involve the productivity losses from reduced nitrate or pesticide use. The logic of employing prevention costs as a surrogate value in use measure for water used to assimilate wastes is clear but the difficulties involved in collecting the data needed are obviously considerable. The costs will vary considerably both between and within industry groups, depending on the technological possibilities, the practicality of making process changes or installing recycling within existing plants, the value of recoverable by-products and so forth. Moreover, the costs incurred could spread far beyond any particular firm; most obviously if the prevention method involves output reduction or plant closure then the impact on the local community and even on the country's balance of payments could be a relevant cost.

Value in use measured by the costs of treating the waste prior to discharge involves fewer data collection problems, although they are, of course, still quite formidable at least for the industrial and agricultural sectors. It does, however, have a number of disadvantages. Most obviously, treatment does not get rid of all pollutants; some will still be discharged into rivers with the waste water, others may be discharged to land as solids or into the air. In addition the treatment option is not present for non-point sources of pollution, nor can treatment costs be a surrogate measure for the value of use of water in dealing with accidental spillages. Despite these disadvantages treatment costs may represent a relatively practical way of measuring crude value in use for water as an assimilator of waste in simple situations. For example in cases, such as sewage plant effluents, where the technology is established and reasonable data exists on the marginal costs of obtaining higher standards of discharge purity and curbing storm overflows in combined foul and storm sewers.

It is important to stress that these different methods of estimating value in use will not necessarily give the same results; indeed it would be highly surprising if they did. From a water resources viewpoint the flow augmentation approach has much to commend it, since it treats waste disposal as any other ex river demand for supplies and raises the possibility of setting marginal/peak prices on a long-run marginal cost of supply basis.

5.3.2 Willingness to Pay for Water as a Waste Assimilator

Several recent reports have reviewed the current experience with pollution charges [ie for direct discharge to rivers]; these include the London Economics (1991) study for the NRA and more substantively, Environmental Resources Ltd (1990), and the various studies undertaken for the Royal Commission on Environmental Pollution (1992B). It is not, therefore necessary to go over this material again here. The salient point which arises from the evidence is that where the charges are set at proper incentive levels, they can act to substantially reduce the pollution loads discharged to rivers. Moreover, as expected, load reductions tend to increase over time as industry takes the opportunity when making other in-plant technological adjustments to adopt waste prevention or treatment measures. However, in few countries are charges set at appropriate levels; low cost recovery or revenue generating charges, not surprisingly, do not have this effect. The existing evidence of responsiveness to pollution charges, while interesting and important in its own right, does not provide us with enough information to assess directly the value of waste assimilation water from the willingness of polluters to pay for it.

Rather more data are available from studies on the impact of trade effluent charges or sewer surcharges, which are typically higher than those generally applied for direct river discharges. Evidence, predominantly from the United States, suggests that the level of industrial discharge is responsiveness to price. Early work (Hanke and Davis 1972, Elliott and Seagroves, 1972 and Elliott 1972) conducted when charges were relatively low, being set only to recover the operating and (often subsidized) historic capital costs of municipal treatment plants, recorded elasticities at or approaching unity. Later studies conducted as real trade effluent charges rose have typically established elasticities well over unity. Such results are not surprising given the economies of scale generally achievable by treating wastes centrally, rather than in a multiplicity of small in-plant facilities.

However, the only two known studies of the response of industry to trade effluent charges in Britain, both conducted in the late 1970s, found it difficult to establish statistically significant relationships between charge levels and disposal levels (Webb and Woodfield, 1979; Rees, 1981). There were behavioural, organisational and capital availability constraints operating which inhibited reaction to charges (these will be discussed in more detail in Chapter 7), but in addition it is possible that the prices set at that time were too low to have any real incentive effect, particularly during a period of rapid inflation. Real prices have risen significantly since 1982, which suggests that today firms will prove to be responsive to the trade effluent charges. Some evidence supporting this view was obtained as part of our investigations of industrial abstractors.

Although the industrial survey was not designed to address waste disposal issues, it rapidly became apparent that effluent charges were becoming an increasingly significant cost element and an important motive for considering water re-use. Concern over waste disposal costs, was a common theme amoung interviewees although only relatively few of them were as yet making concrete efforts to plan their reduction. The case studies given in 4.5.3 serve to demonstrate the importance of disposal costs in water re-use decisions. Interestingly no firms voluntarily mentioned the new NRA cost recovery charges for direct discharge as a motive for water re-use, although one or two referred to possible pollution taxes. This was perhaps surprising given that the new system had only been introduced a month before the survey and should therefore have been fresh in managers' minds.

5.3.3 Surrogate Value Measures

A number of American studies have attempted to estimate the value of water for diluting and assimilating BOD using an alternative cost methodology. Gray and Young (1974), for example, have calculated, for numerous river basins, the relative costs of achieving set river quality standards by increased treatment and the addition of more dilution water. Similar exercises were conducted by Merritt and Mar (1969) and Bramhill and Mills (1966) for single river basins. All these studies found that the marginal value of water for the assimilation of wastes was low. In other words to reach a set river standard it was cheaper to increase treatment than to provide additional dilution water. Although these pieces of research are obviously now very dated, Gibbons (1986) has argued that the general conclusions will still be valid, since the marginal costs of treatment have tended to decline over time, while the marginal costs of additional storage capacity development have increased. However, the value in use would be expected to rise markedly as higher and higher levels of BOD reduction through treatment were demanded.

In Britain two major studies of the Forth Estuary and the Tees, both reported in the Royal Commission on Environmental Pollution's Report on Freshwater Quality (1992), are the only known sources of information on the costs faced by industry of abating discharges to water. These investigations were concerned with the potential implementation of pollution taxes and other forms of regulation and with their ability to achieve set quality objectives through least cost abatement. The Tees study found the normally expected relationship between reductions in waste load and abatement costs, with the cost of investment in abatement increasing (sometimes sharply) with the water quality aimed for. Rather unexpectedly, the work on the Forth found that, for industrial concerns, the per unit treatment cost fell as the total level of BOD reduction increases.

5.4 The Value of Water for Fish Farming

5.4.1 Introduction

The information for this section of the project was primarily obtained from the Humberside International Fisheries Institute, who employed evidence from the literature and from their own experience. In addition a very small scale survey of fish farmers utilizing the Hull River was undertaken to address two specific questions for which no known information existed. First, how far does the existence of an available abstraction licence for fish farm use create land value differentials and second, how do fish farmers respond to and value different supply reliabilities?

Aquaculture in England and Wales is dominated by rainbow trout farming. Whilst there are a few very large farms (>200 tons per annum production), the majority of farms are small, family-run concerns (Table 5.4). The most recent MAFF survey of fish farms in England and Wales recorded 171 sites on-growing rainbow trout for human consumption, accounting for an annual production of about 5800 tonnes (Table 5.4). It is worth noting, however, that the combined

5.4.2 Freshwater fish farming in England and Wales: a brief summary

SIZE OF FARM	NO SITES	TOTAL PRODn (T)
0-9 TONNES	70	219.44
10-24 T	37	515.28
25-49T	17	576.44
50-99T	11	635.80
100-199T	8	1109.40
200T+	6	2244.00

Table 5.4 Production Details from 1990 MAFF Survey of Fish Farms in England-Rainbow Trout Production.

1990 MAFF and DAFS surveys underestimate annual UK production of rainbow trout by about 3000 tons or 25%. On-growing facilities are usually of the earth pond type, although there are some tank-based farms and some floating cage facilities, both in fresh and salt waters. Tank-based production technology is more common in the case of fingerling producers. The degree of vertical integration in the industry is low, probably due to the predominance of small producers. However, most trout farms in the UK are members of the British Trout Association (BTA), formed to represent the interests of the industry and to promote its products. The BTA has been particularly significant in assisting the marketing efforts of the small and medium-sized producers, and as such has made a considerable contribution to the industry's expansion in the last decade.

Other forms of freshwater aquaculture in England and Wales are all marginal activities in comparison to trout farming. Carp are grown for restocking purposes (for recreational fishing) and for human consumption, for which there is a small demand from the Asian and Eastern European communities in the UK. Some ornamental carp are also grown. Salmon farming, whilst dominant in Scotland, is only represented in England and Wales by a handful of smolt producers. Commercial culture of eels is restricted to farms utilising warm water effluent from industry (eg power station cooling water) or to warm water recycle production systems, and there are only a handful of such units in England and Wales. Farming of freshwater crayfish is only practical as a secondary activity, and UK production is insignificant.

Thus trout farms are the only major abstractors of freshwater for aquaculture in the UK, although there are a few significant carp farms; and attention will be focussed here only on these two fish types. There are important differences in the methods used to culture trout and carp, which have significant implications with regard to water resource allocation. Trout farming requires a constant supply of water in large volumes, in order to maintain sufficient levels of oxygen for the fish to respire and to remove toxic metabolic wastes from the fish farm. The amount of oxygen supplied, which is the limiting factor to production, is proportional to the volume of water abstracted. Thus, demand for water is directly related to production and, in the short term, is inelastic with respect to price. However, this situation can be modified by the use of aeration equipment and by re-using a proportion of the supply before discharge.

Carp, in contrast, are cultured in static pond systems. Oxygen is produced within the pond environment by algae, oxygen being a by-product of photosynthesis. Metabolic wastes produced by the fish are degraded to non-toxic compounds by bacteria present in the pond. Abstraction is intermittent and of low volume (in comparison with trout farms). However, the water is held on site for many months before its return to source. Trout farms are, therefore, far more susceptible to variations in water flow than are carp farms.

5.4.3 Assessing the Cost to Trout Farming of Flow Reduction or Insecurity

Farm production per unit volume of water abstracted varies from farm to farm, depending on unit design, feeding methods, temperature and water quality. However, in any one situation, production will be directly related to flow, as incoming water replenishes oxygen, the limiting factor to stock weight. Without artificial aeration, a flow rate of about 1.0 litres per minute per kilogramme of fish present is recommended for yield maximization for pond rearing systems and between 1.0 and 1.25 litres for tank based units. Table 5.5 shows the range of productivities which can be achieved with different culture systems based on these flow rates. It is important to note that, due to the nature of the production, it is holding capacity which is indicated by flow rate and that annual production is greater than holding capacity by a factor of about 2.5. These figures are for the on-growing stage of trout production when fingerlings (about 5 g in weight) are reared to the market size of approximately 300-400 grams. The earlier stage, from eggs to fingerlings, requires about twice the amount of oxygen and, therefore, twice the amount of water.

WATER SUPPLY		HOLDING CAPACITY		ANNUAL PRODUCTION	
(l/min)	TCMD	TANKS	PONDS	TANKS	PONDS
10000	14.4	8	10	20	25.0
15000	21.6	12	15	30	37.5
20000	28.8	16	20	40	50.0
25000	36.0	20	25	50	62.5
30000	43.2	24	30	60	75.0
35000	50.4	28	35	70	87.5
50000	72.0	40	50	100	125.0
75000	108.0	60	75	150	187.5
100000	144.0	80	100	200	250.0

Table 5.5 Water Demand for Trout Farming.

Clearly the water flow/annual production figures are only indicative, since the amount of oxygen carried in the water and available to the fish varies enormously both naturally and due to pollution. Temperature is particularly crucial; research has shown that to obtain the 'optimal' oxygen requirements for growth, one tonne of trout requires, all other things being equal, approximately four times more water when water temperatures rise from 6 to 16 degrees centigrade. Thus water requirements change considerably between summer and winter for the same bio-mass of fish. Inevitably then, reliability of summer flows is particularly critical.

Unless fish farmers have invested in aeration equipment any reduction in flow rates from those expected when ponds or tanks were stocked will have a considerable impact on fish productivity. The actual losses sustained will depend on the level of flow rate (and thus oxygen) reduction and on the stage the fish have reached in the on-growing process. With warnings of flow reductions fish near market size could be removed and sold at farm gate or locally at a loss on full value. Where no warnings occurred or fish size precludes the marketing option, losses through mortality are the potential value of the full sized fish less the costs (feed and labour) of rearing them to full size.

Where the oxygen supply is reduced below the optimum but remains above the absolute minimum required to sustain the fish, then reduced (or no) feeding can reduce the metabolic requirement of the fish. The stock survives and the cost of reduced flows is the reduced growth rate over the low flow period. The actual losses incurred by an individual farmer will vary enormously depending on temperature and the fish size when the flow reduction occurred. Just taking one example, at a temperature of 10°C and with fish size at 25 grams, a two day loss of flow rate (which meant no feeding occurred) would result in a loss to the farmer of approximately £80 per tonne of fish [£1.65 kg ex farm value]. This is a minimum estimate as no allowance is made for the cost of capital tied up in the fish stock, which now takes longer to reach market size. In view of the importance of flow rates to fish farmers, the expectation was that those without aeration in the Hull River survey would be willing to pay a premium for a guaranteed supply; this did not prove to be the case, only two were even willing to consider a reliability premium.

In the longer term, an alternative to a secure supply with dependable flow rates is investment in aeration equipment or water re-circulation; the latter can only be introduced if re-oxygenation also occurs and filtration is installed. Although the introduction of aeration and water re-use allows better use of scarce water resources (Logan and Johnston 1992), the capital costs can be considerable. The actual costs involved per unit of fish stock vary between farms (depending on farm size due to scale economies, farm layout and farming system) and with the magnitude and duration of expected flow reductions, which will determine the capacity required. In view of the large variation in capital costs encountered to meet specific conditions our consultants were not prepared to provide any average figure, arguing that any such figure would produce misleading results. Only one of the three farmers in the Hull River survey with aeration facilities was able to provide detail of costs, and no case of recycling emerged from the sample.

5.4.4 Value in Use Estimation

The most direct method of crudely estimating the aggregate value in use of water for fish farming is to multiply the trout production per megalitre of supply by the market price per unit of fish, deduct all non water operating costs and the annualised capital investment costs and take the residual to be the value of the water employed. The same procedure can also be used employing actual production and cost data derived from farm surveys. This apparently simple method (analogous to the gross margin approach used for irrigation) is, however, fraught with difficulties. In the first place no average unit cost of production data could be established from the literature; moreover any such figures could have been highly misleading given the enormous variation in the size and character of fish farms. Most small farms are owner managed, often as a second job (or hobby activity) or as an offshoot of arable farming. To be commercially viable, it has been estimated that the production of an independent unit should be in excess of 50 tonnes of trout per annum, which implies that some 75% of farms in Britain are uneconomic; the water use in some cases is supporting a lifestyle rather than a commercial activity.

Secondly, the value of the fish production varies depending on the point of sale (in pond, farm gate, local market or major commercial contract). Where the fish are sold purely as food, the best estimate of current values for a portion sized trout (of 300 grams) is £1.65 per kg or between £0.70 - 0.80 per lb; however, farm gate sales can raise £1.30 per lb. Some small farms also sell a proportion of their output as a recreational experience, with a half day fishing licence (allowed one fish) being priced at approximately £10 and a full day licence (three fish) costing £17. Lack of cost data means that no average figure for value in use can be established. The approximate revenue yield however, is £1,600 per thousand cubic metres of water applied, although wide variations around this figure will be experienced in practice.

Only one of the fish farms surveyed on the Hull River was able to give sufficient output, operating and capital cost data, to produce a value in use figure for the licensed quantity of water. The farm concerned was by no means typical, its size producing 350 tons of fish per annum, making it one of the largest in the country. Converting the total investment made into 1991 prices, and assuming a 5% rate of return on investment, produced an extremely low value in use for water of only £1.83 per megalitre. Smaller farms with less capital investment might have much higher values, but this was impossible to test empirically.

For carp no cost of production data could be established. It is only possible to give a very crude estimate of the revenue yield per thousand cubic metres of water supplied. The ex farm price of common carp is approximately £7000 per tonne, and the productivity of carp farming can vary between 1 and 2 tonnes per hectare per year depending on farming methods. In very crude terms at the 1 tonne per hectare per year productivity level, 15 thousand cubic metres of water would be required per tonne of fish output and 7.5 tcm would be needed at the higher productivity level. Therefore, the revenue yield per thousand cubic metres is £466 (at 1 tonne/ha/year) and £933 (at 2 tonnes/ha/year). It must be stressed that these are very approximate figures; they are likely to vary widely from site to site. Clearly these yield estimates are not value in use figures since all production costs are omitted.

5.4.5 Land Values

Water availability and quality are clearly critical for fish farmers: the expectation is that an abstraction licence for a supply with the appropriate flow and quality characteristics will have a major impact on land values. No published information exists on land price differentials, but in Yorkshire it was guestimated from experience that suitable fish farm land could be expected to achieve a 50% premium over arable land. This was borne out by the Hull River field survey; all respondents indicated that a premium would be payable and one posited that suitable land with a good water supply, for which a licence had been issued, could attract a 300% premium over arable land values. Not all this additional land value can be attributable to the water per se since the land itself has to be capable of conversion to an aquaculture unit.

5.4.6 Commercial Realities

It is clear that trout farming has developed on the basis of a plentiful and low cost supply of fresh water. In the short run the demand for water is likely to be relatively inelastic, since farmers with already sunk costs will need to maintain production at roughly current levels to maintain returns on that investment. However, for commercial, as opposed to hobby or low cost sideline, enterprises higher water prices, particularly if set to reflect the peak opportunity costs of provision, could have a marked effect on water demand. Many farmers already appear to be operating at or below the margins of profitability and capital constraints place limits on investment in aeration and re-use. It, therefore, seems likely that significantly higher water prices will force some farmers out of the market.

6. NRA COST STRUCTURES AND COST ALLOCATION

6.1 Introduction

Both the proposed national tariff and existing regional charging schemes reflect the objective set out in the Water Act, that NRA charges recover costs. This has been translated simply and narrowly, as a constraint that regions break-even and base charges on average costs. In this section we consider the nature of NRA costs and develop a cost disaggregation methodology which may form an alternative basis for the setting of charges.

As discussed in Chapter 2, an efficient resource allocation requires that charges are not only related to cost, but set equal to marginal cost. It is widely recognised that this simple rule may be difficult to implement, and may not be appropriate in all circumstances. Moreover, a more general problem is that marginal costs may be difficult to determine where the markets served are inter-related and when the product or service has several characteristics. We have already argued that each abstraction may have several relevant dimensions, such as authorised volume, seasonality, reliability and return flow. Each characteristic which may be varied independently has a potentially identifiable marginal cost.

Marginal cost may be determined through detailed investigation of the underlying technological relationships or may be estimated using microeconometric techniques. However both these methods require much more data than is available from NRA records; therefore the approach taken here is to characterise NRA costs in more general terms. Using the Yorkshire region, the essential characteristics of NRA costs are identified and the prospects of relating prices to these costs are assessed, including the potential to place cost-based prices on activities designed to support the natural environment and other 'in-situ' users.

The essential consideration in developing a scheme of charges based on economic principles is the dual role of prices in a market economy, as a revenue generator and as an influence on consumer choice. The first rule is therefore that prices must satisfy the accounting requirement; typically, that the revenue generated is at least sufficient to offset costs. In isolation, this argument does not take us far, in that many potential pricing schemes may satisfy the constraint; hence the importance of the second rule, that prices should reflect relative costs. The case for marginal cost pricing was discussed in Section 2.2, based on the signal content of prices. Even if there is doubt as to the practicality of full marginal-cost pricing, the central argument remains that prices should induce an efficient allocation of resources. To do this relative prices must be established which at the margin reflect relative costs. In considering charges which more accurately reflect NRA expenditure, we therefore adopt a more specific objective and seek a cost allocation methodology capable of identifying the relative costs of abstraction opportunities.

In the case of water, efficient pricing is further complicated by the existence of substantial common costs. The treatment of these costs is a central issue in developing any scheme of charges. Following the argument above, one concern is to avoid distortion of the signal content of relative prices which is essential if water is to be allocated efficiently. However, prices must also be consistent with an efficient organisational structure for the provision of services. This is considered in Section 6.5 below.

The analysis in this chapter begins with an examination of the preliminary work on cost related pricing conducted by the NRA, highlighting a number of points where the approach fails to address issues of allocative efficiency. Section 6.3 develops an overview of the water resources activity of the NRA's Yorkshire region, so providing a context for the subsequent argument. Selection of the

Yorkshire region was motivated, in part, by a desire to extend coverage of the overall project beyond the Anglian region, but also because we were informed that better cost data was available for this region than for many others. The region's Principal Accountant had also co-ordinated the NRA's preliminary studies on cost allocation and could provide a perspective on some key issues.

It was clear from the outset that the Yorkshire region was unlikely to be representative of the NRA regions in general, as many operate under very different geographic and environmental conditions. Although licence scheme administration and rainfall and river monitoring activities are more or less uniform across the regions, marked differences are noted in the bulk redistribution of water and expenditure on augmentation schemes. It was never the intention to produce generalisable cost disaggregations, but rather to concentrate on cost allocation methods.

Section 6.4 develops a cost attribution methodology, which is illustrated, so far as possible, using data supplied by the Yorkshire region. This is, however, severely limited by the quality and availability of existing NRA cost information and the lack of data on some critical activities of the public water supply companies. However a standard system for the collection of accounting data is being implemented by the NRA, which may simplify future cost attribution exercises.

6.2 NRA Cost Attribution Studies

The existing scheme of licensed abstractions provides a framework for the levying of charges which allegedly reflect the "resources impact" of abstraction. In practice however, NRA charges appear more specifically directed to meeting the objective set down in the Water Act, that income from licensing recovers costs. This requirement has effectively been transformed into a constraint, that charges are based on anticipated average costs, as recorded in regional water resource accounts. Although actual charges may not necessarily fully recover costs in each year, the objective is realised in principle and taking year upon year in practice.

With charges based on operating costs, augmented by a capital cost component, NRA revenues are also the principal source of funding for capital expenditure. The conventions used in determining the capital element in charges have the effect of rationing capital at the regional level. Some relaxation of the regional constraint on investment may be achieved to the extent that resources are notionally pooled and projects in effect funded on an internal market basis from a national budget. Nevertheless, it appears likely that capital may be rationed overall, leading to under-investment. Following privatisation the NRA has demonstrated a tendency to redress the investment constraint by undertaking joint projects with the private water service companies (WSCs), which are less restricted in raising finance for capital projects. Although many such projects may be appropriate and in the public interest, this could result in the neglect of other investment opportunities in which the WSCs have no interest.

In December 1990 the Department of the Environment recommended that future NRA charges be based on attributable costs (i.e. on the expenditure incurred in supplying that particular customer). It was argued earlier (in Section 2.2.4) that for efficiency a scheme of charges should reflect the opportunity costs of abstraction; these may clearly not correspond with attributable expenditure-based costs. Nevertheless, if feasible, an attributable costs scheme may limit the cross-subsidy of one consumer or group of consumers by another and go some way to reducing distortions in the allocation of resources.

Following the DoE's recommendations, the NRA's Water Abstraction Charges Project (WACP) Team conducted a preliminary cost attribution exercise (1991), with the object of assessing the likely effect on the charges faced by particular types of abstractor. Unfortunately, on closer examination, this study suffers from a number of drawbacks, principally because its conclusions were drawn on the basis of total expenditure data. It is argued here that current account transactions must be distinguished from capital formation and it is doubted whether a useful representation of attributable costs can be obtained from total expenditure data. The WACP team evidently agreed with this view:

"It should also be noted that in order to get a genuine representation of the cost attributions, it is not acceptable to regard Revenue and Capital Expenditure as analogous. The point being that, all things being equal, year on year Revenue Expenditure is likely to be consistent in its nature, whereas Capital Expenditure may vary significantly, both in cost and in the purpose for which it is spent. It was therefore suggested that in completing the exercise Regions should consider Revenue and Capital Expenditure separately." (1991, Paragraph 2.2, emphasis added) But in the end no such separation took place.

In an attempt to determine the likely distortions in the results arising from the use of total expenditure data the nine non-Yorkshire regions of the NRA were approached for data which would distinguish between capital and current expenditure. The results are summarised in Table 6.1. As can readily be seen they are rather mixed in terms of the amount of detail available. The percentages in the second half of the table are mostly based on the actual amounts in the first half, except in the case of Severn-Trent where only percentage figures were available.

£'000	ANGLIAN	NORTH-UMBRIA	NORTH WEST	SEVERN TRENT	SOUTHRN	SOUTH WEST	THAMES	WELSH	WESSEX	YORKSHRE	TOTAL
CAPITAL											
HYDROMETRICS	426		560		1333	170	138		339	1200	4165
RESOURCE PLANNING	107		90		0	56	92		0	0	345
LICENSING/ENFORCEMENT	114		55		0	188	115		76	0	548
OPERATIONAL MANAGEMENT	3328		27		316	150	149		0	627	4597
OTHER	0		17		200	64	356		0	0	637
SOURCE PROTECTION	0		0		0	0	298		0	0	298
TOTAL	3975	110	749		1849	628	1147	871	414	1827	10589
REVENUE											
HYDROMETRICS	1539		1973		1468	688	413		657	1021	7759
RESOURCE PLANNING	1408		462		452	938	275		389	100	4024
LICENSING/ENFORCEMENT	1501		349		452	1800	344		507	658	5611
OPERATIONAL MANAGEMENT	3212		11		0	121	447		0	200	3991
OTHER	70		111		116	343	1067		462	40	2209
SOURCE PROTECTION	0		0		181	0	895		0	0	1076
TOTAL	7730	9210	2906		2669	3890	3440	7221	2016	2019	24670
COMBINED											
HYDROMETRICS	1965		2533		2801	858	550		996	2221	11924
RESOURCE PLANNING	1515		552		452	994	367		389	100	4369
LICENSING/ENFORCEMENT	1615		404		452	1988	459		583	658	6159
OPERATIONAL MANAGEMENT	6540		38		316	271	596		0	827	8588
OTHER	70		128		316	407	1422		462	40	2845
SOURCE PROTECTION	0		0		181	0	1193		0	0	1374
	11705	9320	3655		4518	4518	4587	8092	2430	3846	35259

Table 6.1 NRA Resource Cost Split by Region for 1990-91 (Except for Anglian 1991-92

PER CENT	ANGLIAN	NORTH-UMBRIAN	NORTH WEST	SEVERN TRENT	SOUTHRN	SOUTH WEST	THAMES	WELSH	WESSEX	YORKSHRE	TOTAL
CAPITAL											
HYDROMETRICS	10.7		74.8	35.0	72.1	27.1	12.0		81.7	65.7	39.3
RESOURCE PLANNING	2.7		12.0	0.0	0.0	8.9	8.0		0.0	0.0	3.3
LICENSING/ENFORCEMENT	2.9		7.3	0.0	0.0	29.9	10.0		18.3	0.0	5.2
OPERATIONAL MANAGEMENT	83.7		3.6	65.0	17.1	23.9	13.0		0.0	34.3	43.4
OTHER	0.0		2.3	0.0	10.8	10.2	31.0		0.0	0.0	6.0
SOURCE PROTECTION	0.0		0.0	0.0	0.0	0.0	26.0		0.0	0.0	2.8
TOTAL	100.0		100.0	100.0	100.0	100.0	100.0		100.0	100.0	100.0
REVENUE											
HYDROMETRICS	19.9		67.9		55.0	17.7	12.0		32.6	50.6	31.5
RESOURCE PLANNING	18.2		15.9		16.9	24.1	8.0		19.3	5.0	16.3
LICENSING/ENFORCEMENT	19.4		12.0		16.9	46.3	10.0		25.2	32.6	22.7
OPERATIONAL MANAGEMENT	41.6		0.4		0.0	3.1	13.0		0.0	9.9	16.2
OTHER	0.9		3.8		4.3	8.8	31.0		22.9	2.0	9.0
SOURCE PROTECTION	0.0		0.0		6.8	0.0	26.0		0.0	0.0	4.4
TOTAL	100.0		100.0		100.0	100.0	100.0		100.0	100.0	100.0
COMBINED											
HYDROMETRICS	16.8		69.3		62.0	19.0	12.0		41.0	57.7	33.8
RESOURCE PLANNING	12.9		15.1		10.0	22.0	8.0		16.0	2.6	12.4
LICENSING/ENFORCEMENT	13.8		11.1		10.0	44.0	10.0		24.0	17.1	17.5
OPERATIONAL MANAGEMENT	55.9		1.0		7.0	6.0	13.0		0.0	21.5	24.4
OTHER	0.6		3.5		7.0	9.0	31.0		19.0	1.0	8.1
SOURCE PROTECTION	0.0		0.0		4.0	0.0	26.0		0.0	0.0	3.9
	100.0		100.0		100.0	100.0	100.0		100.0	100.0	100.0

Table 6.1 (continued)

Four regions (Anglian, North West, Southern and South West) were able to provide the information asked for (although it should be noted that the Anglian figures are for 1991/92). Anglian was the only region to supply a breakdown by the user categories adopted by the WACP team. The Northumbria and Welsh regions separated capital from revenue expenditure, but could not break these figures down into different activities or abstraction categories. However, it is worth noting that in the WACP report (Appendix 2B, Table 3) 99.89 per cent of total costs in Northumbria are allocated to the water companies and £8,150k of the £9,210k revenue expenditure shown in Table 6.1 is accounted for by "Hired and Contracted - PLC". Thames region argued that a 1:3 split between capital and revenue was as good as could be achieved without a large amount of extra work, and this proportion has been used in Table 6.1.

Wessex region stated that only Hydrometrics and Licensing and Enforcement incurred any capital costs, so all the costs of the other activity categories reported in the WACP study were ascribed to revenue. Finally, Severn-Trent region argued that the activity analysis approach used for the original cost allocation could not sensibly be applied to capital expenditure and moreover, that the split between the two activities which account for almost all capital expenditure in that region varies from year to year.

Few regions responded fully to the enquiries and it appears that the distinction between current and capital account transactions has not always been drawn as clearly as would be desirable. Obviously, the figures in Table 6.1 yield only a limited amount of information and need to be treated with a considerable degree of caution. However, one conclusion is clear: the wide variation between the different regions does come out conclusively. This is illustrated in Figures 6.1 and 6.2, which show the percentage splits between the different activities for the seven regions for which there is enough data in the bottom half of Table 6.1.

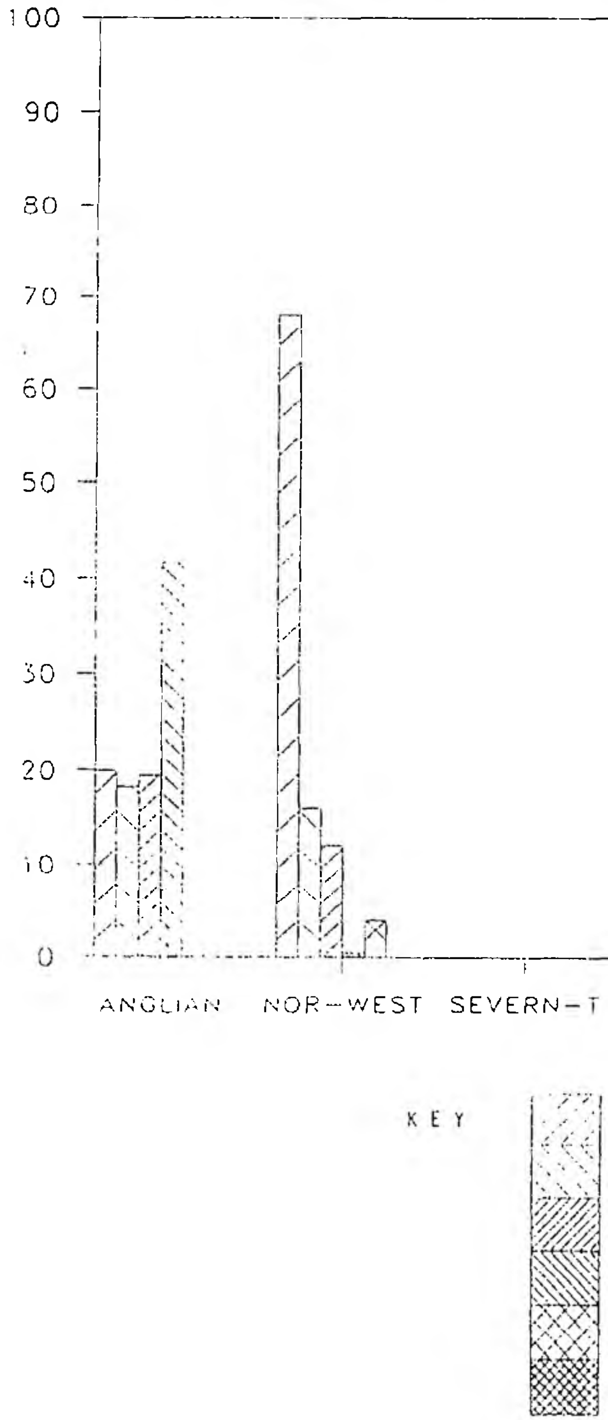
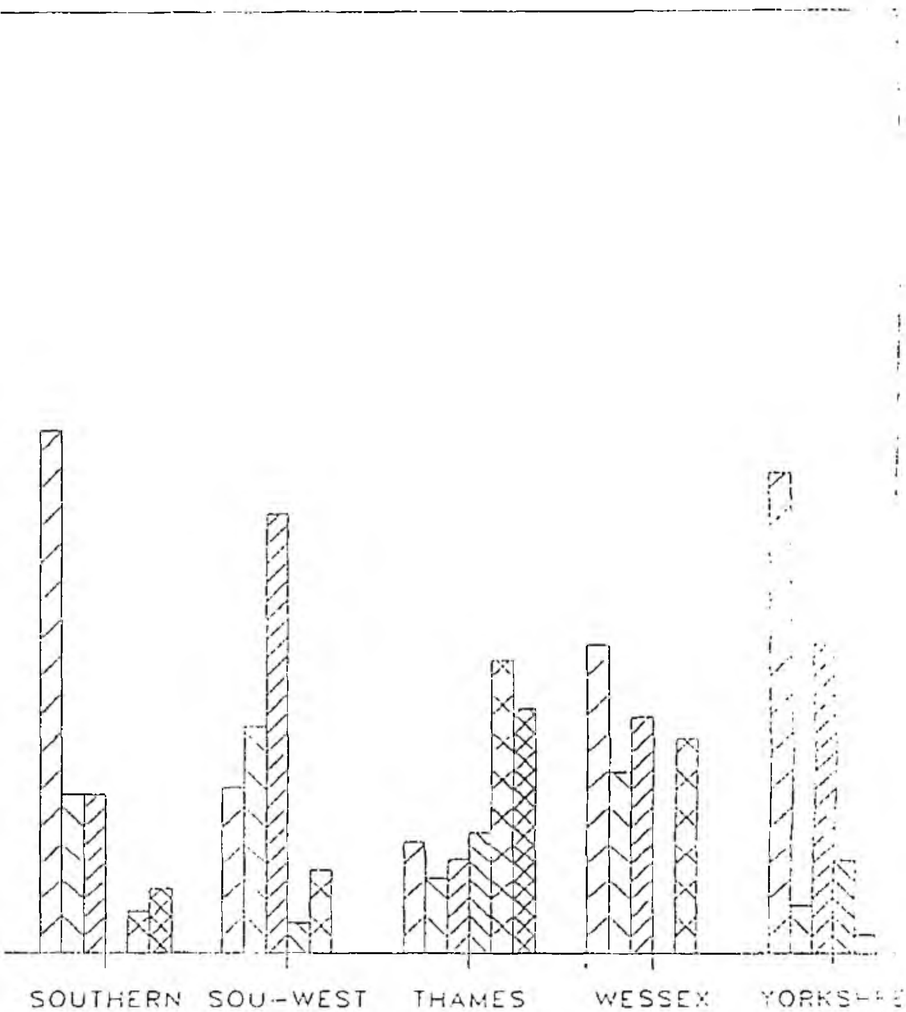


Figure 6.1 Shares of Revenue Expenditure 1990-91 (Except Anglian 1991-92)



Hydrometrics

Resource Planning

Licensing and Enforcement

Operational Management

Other

Source Protection

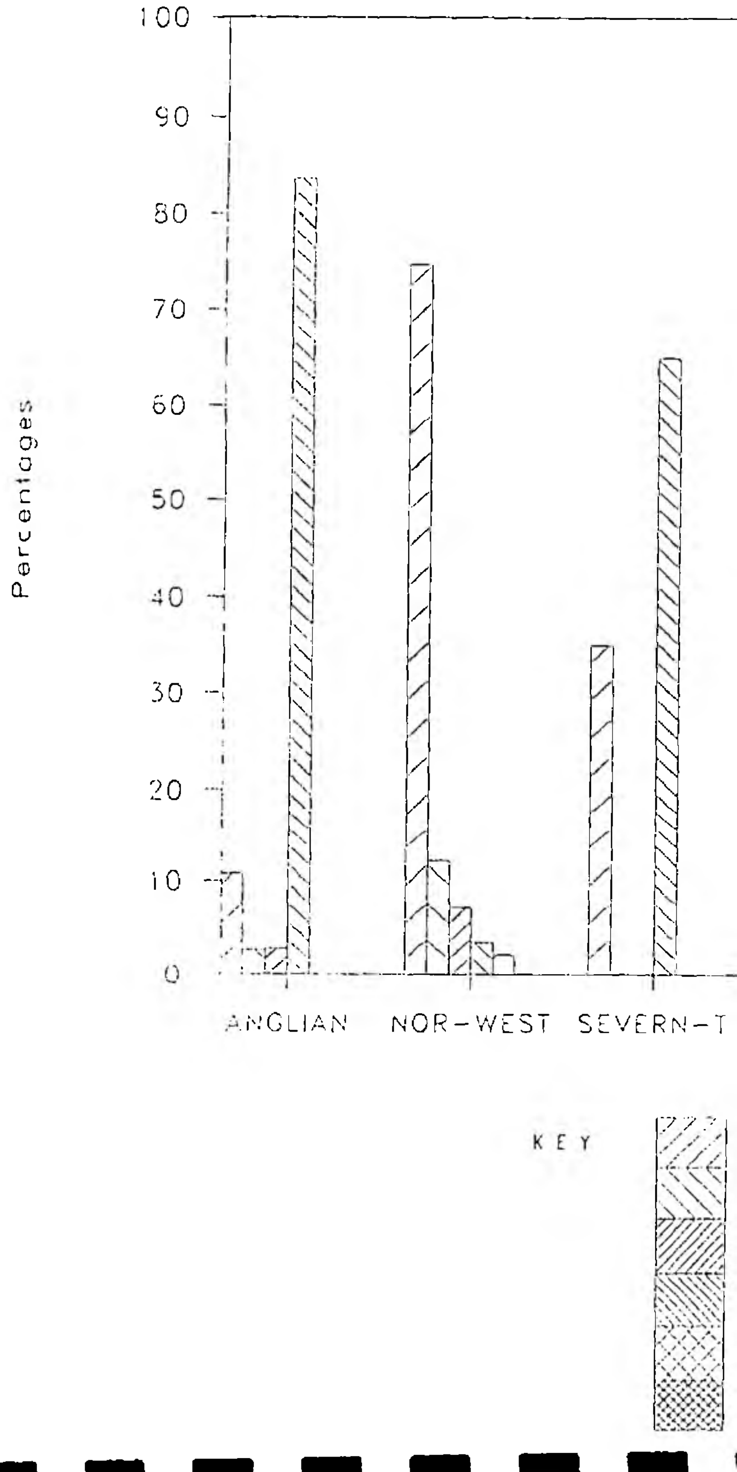
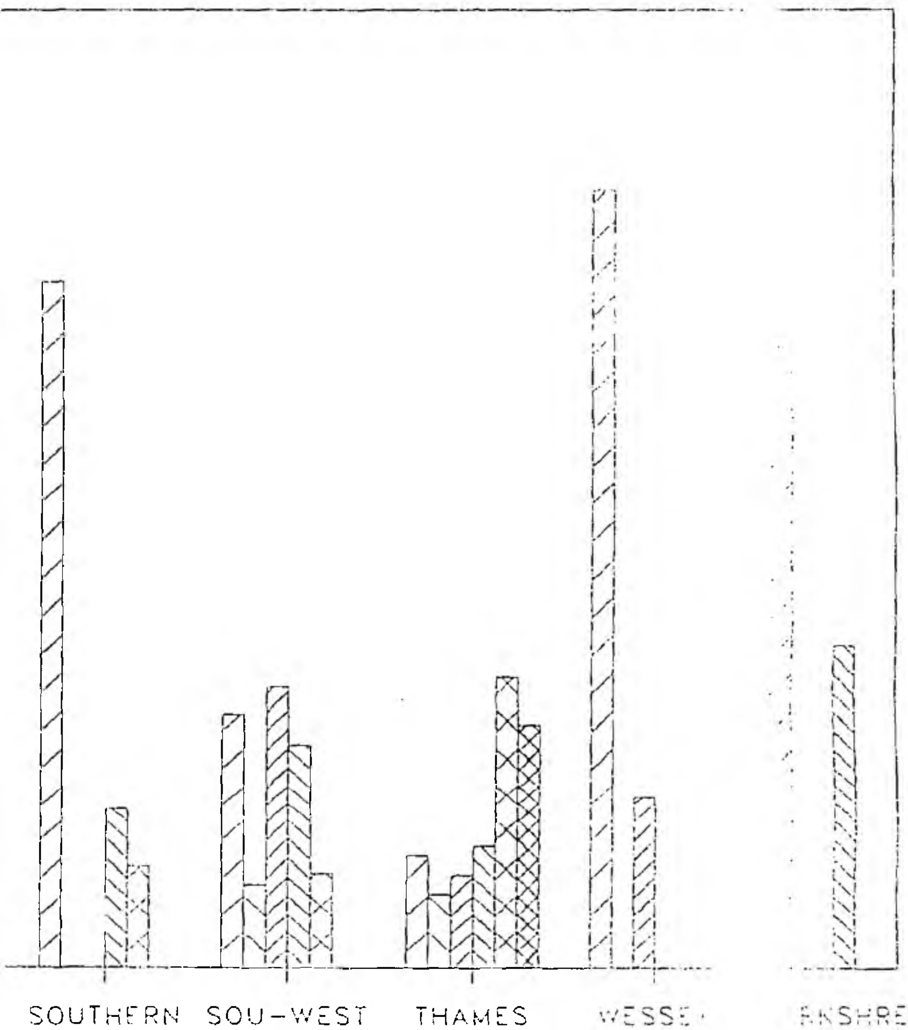


Figure 6.2 Shares of Capital Expenditure 1990-91 (Except Anglian 1991-92)



Hydrometrics

Resource Planning

Licensing and Enforcement

Operational Management

Other

Source Protection

This reinforces the view that a useful representation of attributable costs cannot be obtained from total expenditure data.

A further difficulty with the WACP analysis arises in the assessment of the likely impact of basing charges on attributable cost. It was assumed that the scheme of charges would continue to be a simple licence fee and, implicitly, that the demands of each class of abstractors are perfectly inelastic. The first may prove too inflexible, but if the second property were assured then the basis used in determining charges would be irrelevant from the point of view of establishing an efficient allocation of resources, reducing the argument to one of equity.

Finally, whereas the project team considered the attributable costs associated with broad classes of abstractors, no attention was paid to the nature of the abstraction, which is the critical factor (Chapter 2). The nature of the abstractor is irrelevant except as a proxy for characteristics which themselves determine the opportunity costs imposed by abstractors. Source is similarly irrelevant, unless associated with demonstrable cost differences. On the other hand, NRA activities such as capital projects intended to address problems associated specifically with peak demand should be distinguished. In short, effective implementation of a cost attribution approach requires a much more detailed breakdown of NRA activities and the purpose or objective they are directed to meeting.

In considering refinement of the work already undertaken, there are several more fundamental limitations of the existing accounting framework adopted by the NRA. In the first place, the NRA's present approach is based solely on activity reflected in the water resources account, whereas most NRA activity may, at least indirectly, serve several functions. The resulting problems, although widespread, are perhaps most obvious in capital projects. For example, in assessing the prospect of flow augmentation to meet increased abstraction, rational appraisal by the NRA would also consider (albeit implicitly) the wider implications (both positive and negative) of alternative schemes for other users such as recreation, flood defence and waste disposal in the catchment. Consequently, in devising a scheme of charges it may be more appropriate to adopt a broader framework which can attribute the costs of the various NRA activities to the different functions receiving benefits.

Given the NRA's specific commitment to maintaining and promoting the natural environment, the river itself should be treated as a specific purpose to which activity may be directed in both cost allocation and investment planning. In discussions with representatives of the NRA it has been obvious that objectives are being pursued and constraints exerted, despite the fact that they are not always explicit or well defined. If a scheme of cost related prices is to be operational and effective, it is essential that the purpose of any activity is identified, even in circumstances where charges are not imposed.

Secondly, cost allocation exercises based on existing structures are flawed in their failure to recognise the existence of common costs which, by definition, cannot be uniquely allocated among consumers. Common costs are inherent in most NRA activity, an obvious example being the costs of general support services and some headquarters functions. Cost attribution in this case is arbitrary and in practice is often made subjectively, according to "gut feeling" or following an accounting convention. The danger is that, although this recovers costs, it can lead to some consumers facing relative prices which establish incentives leading to a perverse allocation of resources.

Further distortion may arise from the treatment of investment expenditures and capital assets. It was noted above that in most regions expenditures on physical capital and current expenditures are apparently not routinely identified in disaggregated data. In the absence of inter-regional transfers, investment is effectively funded directly from revenues, with physical capital formation being largely determined by accounting conventions, such as the depreciation factor. Under these conditions, resources may not be allocated efficiently, because capital projects which are justified on economic criteria may be rejected due to the capital budgeting constraint. Alternatively, the rate of return factor may be raised to provide the revenue required, in which case current consumers are burdened with charges associated with assets which primarily benefit future consumers. Where this results in charges which the marginal consumer is not willing to pay, such a scheme may also distort the allocation of resources.

In proposing a scheme of charges based on attributable cost, the present study advocates a fundamental change of perspective in the treatment of physical capital inputs. The relevant issue for pricing is the value of the services obtained from capital in each market period, which may be referred to as the <u>rental price of capital</u>. In some isnstances, such as vehicles, the concept of the rental price is intuitive. Rather than purchase the capital asset outright and utilise it over several market periods, the services of the asset may be obtained at a market price. For the purposes of cost attribution it is the rental price which should be allocated, rather than the cost of the asset itself. Although conceptually simple the concept of the rental price may prove difficult empirically, particularly in the case of assets specific to a particular activity, where the services of the asset are not directly marketed. In these cases a rental value must be constructed. Fortunately, the assets of all the NRA regions were valued at vesting day, simplifying the process of estimating a rental value.

An apparent drawback of cost attribution methods based on the rental value is that prices will not necessarily generate the revenue required to finance the economically efficient programme of investment in each period. However, it should be clear from the preceding discussion that the same is true of the present approach and indeed, any other scheme which denies the NRA access to financial capital.

A cost attribution approach based on NRA data will also prove unsatisfactory unless it is recognised that water resource management is often achieved through the indirect use of physical capital assets in the hands of the private water companies. Here the principal concern are reservoirs which, although owned and operated by the WSCs, may have a considerable and potentially under exploited impact on the catchment. Clearly reservoirs and other installations are essential for large scale abstraction by the companies, but most, if not all installations used in the management of untreated water can be regarded as components of the water resource infrastructure, with a significance beyond their role in meeting 'urban' demand. Consequently, although the NRA may face no accounting costs in connection with these assets, their rental value is potentially an important element in economic costs, to the extent that they are (indirectly) employed in meeting NRA objectives. Part of the current expenditures of the water companies may also be attributed to NRA-related activity.

Arguing that full cost-based abstraction charges have to take account of water company costs inevitably raises issues concerning the ownership and operation of the water resources infrastructure. While recognising that such matters are, and have been, determined politically, in economic terms the following division of assets would have been desirable. Where reservoirs are regarded simply as storage facilities for water abstracted by the water companies, then the assets should rationally be put in the hands of the abstractor. However where the infrastructure is or could be used in managing the catchment it should logically be owned and operated by the NRA, which is charged with the task of developing water resources. This latter situation is the norm, although by no means the universal case. Given that the current allocation of assets does not follow this division it is important that an economic relationship is established between the parties which leads to an efficient allocation of water resources. In the subsequent analysis it is argued that the existing arrangements do not, at present, meet these criteria.

Given this approach to the water resources infrastructure a further difference arises with the WACP report, in that the situation in the Northumbria region is now seen as being closer to the economic ideal than that in other regions. The exceptional circumstances in Northumbria arise from the NRA's involvement in the Keilder Scheme, under Section 126 of the Water Act, rather than recognition of the potential role of impoundments in water management. The fact that following privatisation investments have been undertaken as joint ventures with the companies will raise the share of infrastructure costs attributed to the NRA. In such cases, the principal concerns are that the attribution of the rental value is appropriate and that, given the differences in access to financial capital noted earlier, NRA investment activity is not subject to <u>capture</u> by the companies. Given the long lifetime of the water infrastructure, the role of WSC assets and the treatment of their associated rental value will remain an important issue.

6.3 Yorkshire Region NRA

Selection of the Yorkshire region as the basis for our investigation inevitably focuses attention on a narrower range of issues than a national study would. However, it should be noted that some apparent regional costvariations may simply be the result of differences in accounting conventions and established relationships with the water companies. In generalising over the regions, more significant issues arise from variations in the pattern of abstraction, due to environment and geography, leading to distinctive water management problems. Although the Yorkshire region is not regarded as representative it is not atypical either, in that it demonstrates many characteristics which a pricing scheme based on economic principles must address. The major potential difficulty involved in the use of Yorkshire data is the existence of the treated water grid, which moves potable supplies across the region.

With operating costs in the order of £1.5 millions, the Yorkshire region covers an area of some 5,200 square miles, with 13 main rivers managed as 34 sub-catchments. A broad comparison of the regions may be drawn from the report on cost recovery prepared by the Water Abstraction Charges Project Team (1990), which is summarised in Table 6.2. In terms of income from abstractors, the region received a much smaller proportion of its revenue from the WSC sector than any other region (67% in 1989/90, against the national average of 89%, falling to 63% by 1990/91). This may be at least partly explained by the currently higher share of revenues from industrial users. Spray irrigation, which has been identified as being of particular interest to the NRA, is relatively unimportant in the region, with 524 licensees yielding only 1.6% of revenues in 1989/90. Detailed investigation of the issues specific to spray irrigation would be better conducted in terms of the Anglian and Severn-Trent regions which together account for 46% of licences and 85% of revenue from spray irrigators.

Broad inter-regional comparisons may be made in terms of revenue shares and the number of licensed abstractors, but these convey little information about a particular region. A more informative picture may be developed in terms of the summary of authorised abstraction volumes, given in Table 6.3 and derived from the register of licensed abstractors for 1991/2. This casts the WSC sector in a somewhat different light, in that it accounts for 840,235 tcma, only 42% of authorised abstraction volume, of which some 16% is groundwater. Thus in licensed quantity terms the share of the water companies is less than that due to

	Water Cos N	Water Cos £000	Large Ind N	Large Ind £000	Spr Irrig N	Spr Irrig £000	Fish Farm N	Fish Farm £000	Cooling N	Cooling £000	Oth Signif N	Oth Signif £000	Miscellan N	Miscellan £000	TOTAL N	TOTAL £000
Anglian	8	6065	0	0	2300	1030	0	0	1	27	0	0	1311	789	3620	7911
	0.2	76.7	0.0	0.0	63.5	13.0	0.0	0.0	0.0	0.3	0.0	0.0	36.2	10.0		
Northumbria	4	20988	0	0	0	0	0	0	0	0	0	0	254	95	258	21083
	1.6	99.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.4	0.5		
North West	4	1693	6	227	360	26	25	4	108	23	0	0	940	171	1443	2144
	0.3	79.0	0.4	10.6	24.9	1.2	1.7	0.2	7.5	1.1	0.0	0.0	65.1	8.0		
Severn Trent	10	15389	4	1354	784	841	10	1	0	0	1	56	2009	450	2818	18091
	0.4	85.1	0.1	7.5	27.8	4.6	0.4	0.0	0.0	0.0	0.0	0.3	71.3	2.5		
Southern	11	3414	6	248	1050	125	6	1	50	3	22	90	345	64	1490	3945
	0.7	86.5	0.4	6.3	70.5	3.2	0.4	0.0	3.4	0.1	1.5	2.3	23.2	1.6		
South West	2	3590	139	220	333	19	45	1	14	1	679	15	40	1	1252	3847
	0.2	93.3	11.1	5.7	26.6	0.5	3.6	0.0	1.1	0.0	54.2	0.4	3.2	0.0		
Thames	12	3027	1	44	258	15	2	70	0	0	0	0	1181	280	1454	3436
	0.8	88.1	0.1	1.3	17.7	0.4	0.1	2.0	0.0	0.0	0.0	0.0	81.2	8.1		
Welsh	5	12541	4	405	568	33	45	2	53	79	14	134	1215	465	1904	13659
	0.3	91.8	0.2	3.0	29.8	0.2	2.4	0.0	2.8	0.6	0.7	1.0	63.8	3.4		
Wessex	5	1948	230	125	460	80	5	2	0	0	300	25	0	0	1000	2180
	0.5	89.4	23.0	5.7	46.0	3.7	0.5	0.1	0.0	0.0	30.0	1.1	0.0	0.0		
Yorkshire	5	1626	4	504	524	40	35	1	0	0	0	0	880	269	1448	2440
	0.3	66.6	0.3	20.7	36.2	1.6	2.4	0.0	0.0	0.0	0.0	0.0	60.8	11.0		
TOTAL	66	70281	394	3127	6637	2209	173	82	226	133	1016	320	8175	2584	16687	78736
	0.4	89.3	2.4	4.0	39.8	2.8	1.0	0.1	1.4	0.2	6.1	0.4	49.0	3.3		

Notes: Lower row in each case is percentages, adding horizontally
There are some discrepancies between regions in some categories
Some Water Company customers are actually other NRA regions

Table 6.2 Numbers of Licences (N) and Receipts (£000) by Region, [illegible]

	tcma	%
Spray Irrigators		
Two-Part Tariff	17,644	
Simple Tariff	237	
	17,881	0.9
Ordinary Abstractors	542,081	27.0
Public Water Supply (incl. York Water Works)	840,235	41.8
British Waterways Board	12,522	0.6
Electricity Generators	594,885	29.6
TOTAL	2,007,604	100.0

		tcma	%
Sources of Water Company Supply: (excl. York Water Works)	Ground	127,709	15.9
	Surface	642,685	79.8
	Unclear	34,837	4.3
		805,231	100.0

Table 6.3 Authorised Abstractions-Yorkshire Region

electricity generation and other industrial users which make up the majority of ordinary abstractors.

In broad terms, the task of water resources management in the region may be characterised as arising from the geographical disparity between demand and supply. Supply is concentrated largely in the Pennine hills to the west of the region, with some groundwater mainly in the north and east, whereas the urban demand centres are concentrated in the central and southern part of the region. In addition, the majority of industrial abstractors are located largely, but not exclusively, in the south and west of the region, whereas spray irrigation tends to be concentrated in the drier north and east. Consequently, the region tends to divide into two zones, with little conflict between industrial and other users.

The geographic imbalance between demand and supply has been addressed by the Yorkshire River Authority and its successor company, through the establishment of a supply grid conveying treated water to the main demand centres. Treated water is also imported from Severn-Trent Water PLC to supply the Sheffield area. Consequently, in terms of treated water, the Yorkshire region can be regarded as a partially integrated system. Although the concern here is not with treated water and the operation of the grid, it clearly has implications for the management of raw water.

Operationally, water resources management in the region has changed little following privatisation. This is not particularly surprising given the importance of abstraction by the company sector, the technical factors which integrate the industry and its overall stability. Although (at the time of writing) there are no formal agreements with the companies over capital assets, in common with other regions, proposed investment is increasingly taking the form of joint ventures: for example, augmentation in the Ouse catchment, from boreholes in the

Boroughbridge area, north of York. The principal beneficiary of this scheme is the water company abstracting at Moor Monkton north of York, although the NRA also expects to improve conditions for spray irrigators in the catchment.

There is of course no fundamental objection to joint ventures of this type, and at present there are no signs that overall investment is subject to capture by the dominant WSC sector. However in cases where the financial capital comes predominantly from the companies there are dangers that the NRA may be unable to exert sufficient influence on decisions to realise the maximum potential gain from the project. Other new capital projects include the proposed Driffield augmentation scheme, which would increase flows in the River Hull by augmenting supply from boreholes near Burton Flemming. In this case the motivation is mainly environmental, although there are likely to be some benefits for fish-farmers and the WSC abstracting downstream.

Surface water resources in the region are managed in two main ways; reservoirs in the Pennine hills impound water in the upper reaches of most western catchments, while the ponding of a major catchment, the Derwent, close to its confluence with the tidal Ouse, reduces outflow to the sea. Although both techniques have the effect of retaining water in the catchment, there are important differences between them. Impoundments in the head-waters of a catchment may materially affect abstraction opportunities downstream, and the intrinsic value of the river for 'in situ' users. On the other hand, water denied to the sea has no opportunity cost (see Section 2.2.2). This is the case with the Barmby sluice on the river Derwent, where water is obtained by preventing outflow to the sea.

The issue of opportunity cost can be clarified by contrasting this situation with abstraction for the water grid from the Derwent some 14 miles upstream, at Elvington, where the opportunity costs should reflect the impact on actual and potential abstractors and in-river users downstream. Such opportunity costs might have far reaching consequences, and require careful evaluation. (The word 'potential' is emphasised here since the current 'first come, first served' allocation system and the informal pre-application licence refusal process may have deterred some from expressing their latent demands.) An opportunity cost approach also implies that river water will typically have a lower economic cost where abstraction occurs in the lower reaches of the catchment. This applies with particular force when the use of water is consumptive or it is not returned to the catchment.

Even in a situation where the opportunity cost of the water per se is zero, such as abstraction at Barmby, the opportunity cost of the resources used in making the water available must also be considered. In the case of abstraction, these are current expenditures on water management and the rental value of both NRA and any water company capital assets, either directly or indirectly employed. Consequently, in setting prices based on economic principles, there is a major difficulty in that the costs attributable to the WSC sector include the rental value of its own assets. This problem is not simply solved by setting the abstraction charge for the water company net of the cost component attributable to its assets. To do so, would be to advocate prices which systematically fail to reflect the relative opportunity cost of meeting competing claims. Rather the solution lies in the water company setting appropriate charges for the use of its assets by the NRA and then being subject itself to the same cost-based charges as other abstractors.

To a very limited extent the water company also uses one river in the Yorkshire region as a conduit, transporting raw water for abstraction. In this case, the rental price of NRA capital assets employed and current expenditures arising from activity undertaken by the NRA in supporting this service should be attributed to the company. Such activities and related expenditures may be identified relatively easily as those which would be unnecessary were the river not to be used for this purpose.

The primary role of water company assets in water management arises in connection with the many reservoirs in the Pennine hills. Owned and operated by Yorkshire Water PLC, such reservoirs impound water, affecting flows and abstraction opportunities throughout the catchment. The licensing of abstraction from these includes a specified (minimum) release of water in the form of a compensation flow. To the extent that the operation of reservoirs may reduce the winter rate of flow and increase the rate in summer, they have an important water management role in maintaining a base rate of flow and making water available for abstraction from the river. It is from this perspective that the argument is made that these company assets are employed in meeting NRA objectives. Ironically, setting aside flood control and other considerations, as a water management resource the Barmby sluice is an NRA asset which largely serves the WSC sector and could be made a WSC asset without distortionary effect.

Accepting that reservoirs have a role in water management, it must also be recognised that the institutional arrangements for compensatory releases may be inefficient. At present compensation flows are effectively negotiated between the WSC and NRA, but subject to parliamentary approval. Consequently, the frequency and scope of such negotiations is likely to prove much too inflexible in a system driven by economic incentives. For example, following the recent droughts the companies may wish to reduce the rate of compensation flow in order to make more water available for treatment, whereas the NRA might wish to increase flows to enable abstraction elsewhere, or simply maintain the river for its own sake. Past agreements allow little scope for resource reallocations except in the unlikely circumstances that changes in compensation flows benefit all parties.

Given the conflict between the parties and an emphasis on the promotion of an efficient allocation of resources, there is a strong case for reform of the existing arrangements. In particular, a more flexible relationship between the NRA and the companies is required in the determination of compensation flows, irrespective of the ownership of the physical infrastructure. Subject to the establishment of appropriate bargaining arrangements between the parties, the ideal would be a market-like arrangement over releases of water from impoundments, with the prospect of attaining an appropriate balance between competing uses. However it is recognised that attaining such a balance depends upon there being some symmetry in bargaining power.

Although, in principle, such a market relationship can be established with relative ease, given the existing institutional relationships it may, in practice, require regulation. At present, impounded water becomes the property of the company and subject to the terms of the abstraction licence, such as the compensation condition, is available for abstraction. If the compensation condition were removed and replaced with a market in "water for release to the river", the company, in setting the price of such water, may include an element of monopoly rent associated with its near monopoly over the market in treated water. Therefore, although there is a prospect of increased efficiency, in the absence of regulation of the market transaction, it is again possible that the price signals in market trading may be distorted. The upshot is that the NRA, with the responsibility for maintaining the river, may face distorted relative prices which induce the systematic under-purchase of water to maintain the river, with all the attendant environmental consequences.

6.4 Cost Attribution Methodology

6.4.1 Introduction

In developing a methodology for the attribution of costs, a broader framework is adopted than that envisaged in the work of the Water Abstraction Charges Project team and present NRA practice. In particular, although a basis for water pricing is developed, drawing on the earlier arguments, costs cannot be considered solely in relation to abstraction. The preferred approach recognises that NRA activity supports a range of objectives and users, some of which presently attract no charges. Whether such users are to be charged in the future is not the prime concern here; rather the emphasis is on ensuring that, when attributing costs to users, the range and motivation of activity undertaken by the NRA must be fully understood.

Traditionally, cost analysis has been regarded as inappropriate for utilities and service industries, primarily because direct costs are relatively small and overall costs vary little with the rate of output. These same characteristics are conveyed, less precisely, in the claim that costs are mainly in the nature of <u>overheads</u>. The approach advocated here is similar to that of Dearden (1978), which emphasises the activity undertaken in supplying <u>services</u>: that is in attaining particular objectives and serving specific users. There will however be some activities, and hence costs, which are genuinely not attributable to specific services, because they support two or more services in <u>common</u>. Although such costs pose no particular problems, they must be offset by revenues where a break-even constraint is applied . <u>Common costs</u> therefore require separate and more detailed treatment, which is deferred to Section 6.5, in order to focus on cost attribution.

A scheme of charges based on economic principles requires the calculation of two components; the opportunity cost of the resources employed in making water available (i.e. in water management) and the opportunity cost of the water itself.

In developing the cost allocation methodology only the first of these is considered in detail. The principles involved are exactly the same for the allocation of the opportunity costs of the water itself, but since these are determined by catchment-specific factors, the scale of the abstractor and its location, for simplicity they have been omitted from the analysis.

Implementation of a scheme of charges based on economic costs requires an operationally relevant breakdown of NRA (and some WSC sector) activity. With this established, each activity may then be attributed to the specific services supplied and the associated costs allocated accordingly. In effect, the approach may be characterised as one based on a concept of avoidable costs, in the sense that attributable costs are identified as those not incurred if the particular service were suspended. For example, if the NRA's costs would fall by £N million if it abandoned its flood defence role but kept its other activities unchanged then that sum would be a cost uniquely attributable to flood defence. However if a large proportion of the costs associated with flood defence are common costs also associated with one or more other activities, then the attributable cost may be quite small. For a new service the equivalent approach would be to look at the incremental cost of adding that service. In the long run this will be the same as the avoidable cost of abandoning it.

6.4.2 The Hierarchical Approach

The specific framework recommended by Dearden considers a hierarchical breakdown of services which starts with the most comprehensive definition and then moves downwards through that hierarchy to progressively less comprehensive definitions. In the present case the most comprehensive definition covers the NRA as a whole, plus any relevant water management activity undertaken by the water companies, whereas the least comprehensive is associated with services to an individual final water user (for example a particular spray irrigator). The system proposed here for the NRA is shown in Figure 6.3.

Given the hierarchy, the approach works as follows. First activities at the highest level are, so far as possible, attributed to the subordinate unit in the hierarchy, leaving only activities which serve all the subordinate units in common. By a process of iteration over all levels in the hierarchy, activity is allocated as far down the hierarchy as possible, so that activity specific to a particular service is identified, as is activity directed to a specific category of services in common. In the case of staff time or some items of equipment, for example, activity may be allocated to the individual abstractor, in others to the appropriate service category, such as "in river users" of a particular (sub-) catchment. In the case of very general management activities the costs may be allocated to all water users in common, whereas the whole, or more likely, part of the activity of, say, the Water Resources Manager might reasonably be attributed to all abstractors in common.

Assuming an appropriate scheme for the pricing of services provided in house, it is likely that, with the possible exception of transactions involving the water companies, the NRA obtains inputs in near perfect markets. The accounting costs incurred by the NRA can therefore be taken as a good approximation of the opportunity cost of those resources. Consequently, the essential requirement of the recommended approach is a routine audit or monitoring of activity. There are, however, implications for the computation of costs (and prices), because in the nature of the approach, the cost of any service is partly composed of elements common to each superordinate level in the hierarchy. The allocation of common costs at each level is central to the efficiency of the charging regime. Dearden advocates the division of the common costs of each hierarchical unit among subordinate units in proportion to the latter's attributed costs, achieving an

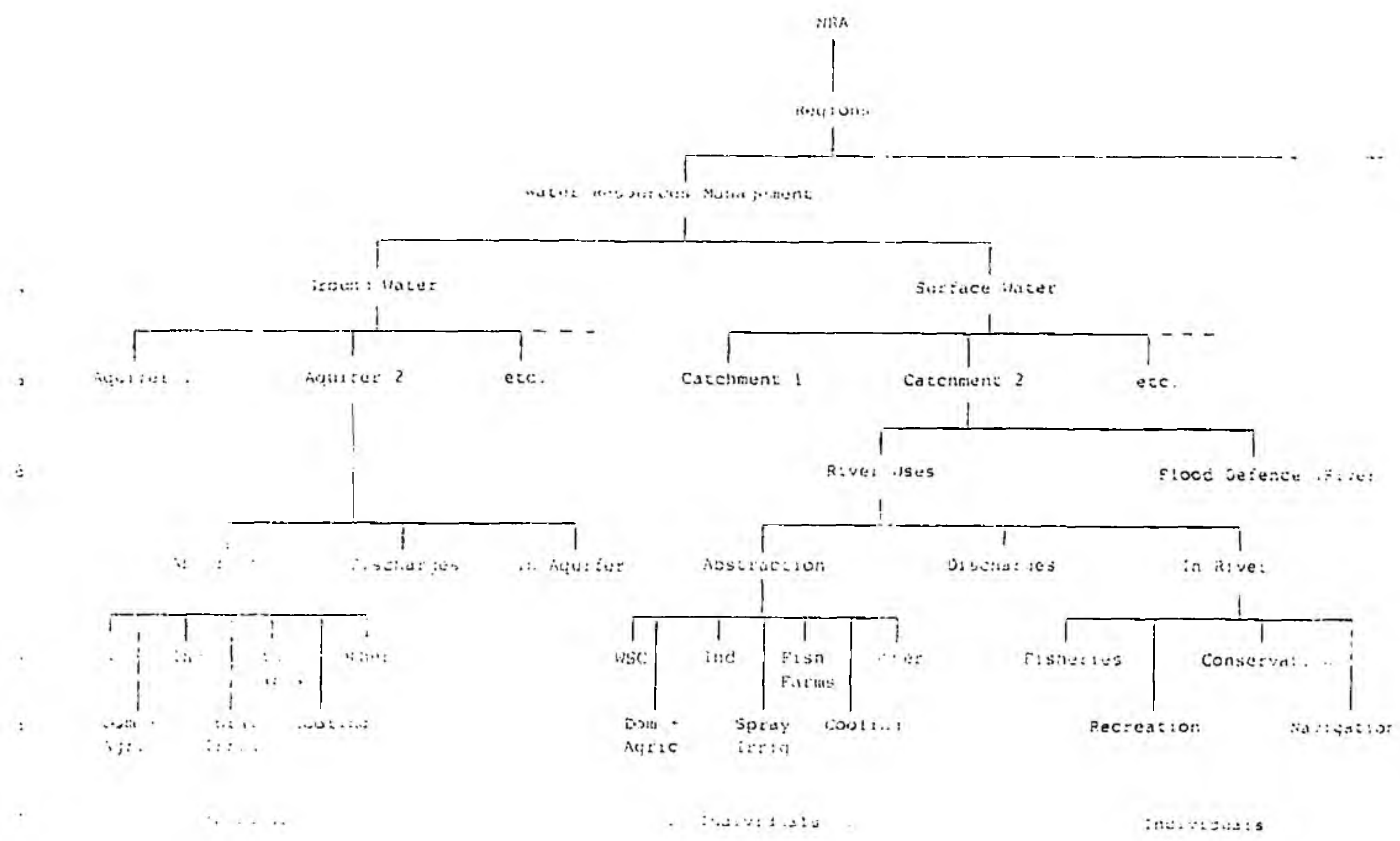


Figure 6.3 Proposed Cost Allocation Hierarchy for the NRA

exhaustive distribution of costs across the system as a whole. Although this rule may have some appeal from an administrative point of view, it is only one of several possibilities which must be reviewed. It should be noted, however, that this approach will be particularly affected by the sensitivity of the process of cost attribution. For example, a service which is deemed to have no specific costs would bear none of the common costs of the immediate superordinate level, so that its attributed costs arise only at higher levels in the hierarchy.

The detailed application of this methodology and in particular, how far down the hierarchy costs can in general be allocated causally, is conditioned by the availability of information. This is shown clearly by the tentative illustration for the Yorkshire region discussed below. Nevertheless, it is worth noting that the American Federal Communications Commission claim that in a well-designed cost allocation system some 80-90 per cent of costs can be assigned on a direct or indirect cost-causative basis. Thus the amount due to activity common to all services - a general overhead element - should be low.

6.4.3 The Proposed Hierarchy

The reasoning behind the particular scheme shown in Figure 6.3 is as follows.

The highest level is the NRA, augmented by any relevant activity undertaken by the water companies. Although the NRA is a national body its regional structure is a strong one, partly because of its historical origins in the old RWAs but also because the regional boundaries largely follow natural watersheds between catchment areas. Thus the first branch in the hierarchy (Level 2) is into regions.

The NRA identifies seven core functions in its operations: Water Resources, Pollution Control, Flood Defence, Fisheries, Recreation, Conservation, and Navigation (see the Corporate Plan 1990/91). This does not seem to be the best division to follow for cost allocation purposes; in particular given the subsequent argument the Pollution Control function is better treated as a range of activities with costs to be allocated over the hierarchy, rather than as a separate function. On the other hand, coastal activities (where they exist) do appear distinct from others within a region; being mainly flood defence and harbour navigation. We therefore have only two branches at Level 3, Water Resources Management concerned with rivers and aquifers and Coastal Management. As coastal issues are not of concern here this branch is not developed any further, except insofar as it remains relevant in the allocation of the common costs of activity at superordinate levels.

A feature that emerged from the study of the Yorkshire region, but which is of general applicability, is the strong separation between surface and ground water resources. Given the emphasis on the activity of managing water this division is employed at Level 4 in the hierarchy. Geographically they are unlikely to coincide, as aquifers often extend under a surface watershed. it is recognised, however, that ground and surface water systems can be inter-related; this could affect the opportunity costs of the water but has negligible effect on the costs of management. Groundwater is divided into different aquifers, each of which has three possible uses: as a source of abstraction, (in principle anyway) as a recipient for discharges, and within the aquifer itself to maintain ground water levels, prevent saline intrusion and so forth. Discharges are not the subject of this study, except with regard to common cost allocation and are largely set aside.

Abstractions can then be further divided according to their characteristics. The divisions employed here - Water Companies, Domestic and Agricultural, etc., - follow existing NRA practice but should be regarded as proxies for the relevant characteristics. Each of these groups is further divisible into individual licence-holders, but these are not shown in the diagram.

Surface waters are similarly divided into catchments, but have a more complicated structure of uses. As was done further up the hierarchy, flood defence, which amounts to a negative demand for water in the river at certain times of the year, is separated from other river uses, which all make positive use of the water in the river. Also a large element of costs within the catchment is for pollution control, which does not really benefit the "users" of flood defence. River Uses then has the same split as ground water, but the 'in river' category is then divided into separate functional groups. Four of the NRA's core functions - Fisheries, Conservation, Recreation and Navigation - are 'in situ' uses which we group in terms of The River as an end user. The justification for this grouping is strengthened by the way many regions have merged the first three of these into an "FCR function" already.

A substantial element in pollution control is linked to discharges and, although they are not of direct concern, their treatment in the proposed scheme should be noted. Authorised discharge is treated as a legitimate use of the catchment (or aquifer), on the same terms as abstraction and 'in situ' use, recognising that it may be justified economically. An implication of this is that those who discharge to rivers may also stimulate water management activity and may be required to bear some part of the common cost arising at superordinate levels in the hierarchy. Activity associated with unauthorised discharges, such as monitoring and prosecution, will in the main tend to be catchment (or aquifer) specific and benefit all subordinate levels in the hierarchy. The associated costs will mainly be common at catchment (aquifer) level.

Having devised a hierarchy, two main words of warning need to be sounded. One is that the structure in Figure 6.3 is to some extent based on the pattern of costs and activities in the Yorkshire Region, and minor changes may be needed in applying it to other regions. The second is to note that some of the elements will inevitably be inapplicable in individual applications; however, the objective is to be comprehensive at this stage.

6.4.4 An Illustrative Application; The Yorkshire Region

Under the scheme proposed, the cost based tariff associated with any particular service may be thought of as comprising four components; i) the current costs of activity specific to the service, ii) the rental value of capital assets employed in activity specific to the service (including WSC assets, such as reservoirs indirectly employed in maintaining compensation flows). To these attributable costs must be added, iii) the common costs component, an aggregate of allocations of common costs at superordinate levels in the hierarchy and in the case of abstraction, iv) the (social) opportunity cost of the water itself, which may be zero.

Ideally values could be derived from the hierarchy shown in Figure 6.3, or at least something like it, for the Yorkshire region of the NRA. However the information available to us relates only to the Water Resources function of the Authority, whereas the hierarchy in the diagram requires information on activities (such as flood defence) which are presently accounted for separately. Moreover, due to the way in which the data is collected, the motivation for much of the activity underpinning the recorded costs cannot easily be identified.

Clearly, the data currently available does not allow us to attain the Federal Communication Commission's suggested target of a causal allocation of 80-90 per cent of costs (see Section 6.4.2 above). Nevertheless, it is worth considering what the data can yield and, in particular, distinguishing those activities where costs are identifiable given present accounting systems and those where they are not. Capital and current expenditure are considered separately.

(a) Current Account

Turning first to current ("revenue") expenditure, the region spent some £1.9 million in 1990/91; see Table 6.4. Under the present accounting system some of this spending is allocated quite precisely to individual purposes, but other sums are not. Most detail is available for spending on the Barmby barrage at the confluence of the Derwent and the tidal Ouse, individual river gauging stations (RGS), rainfall gauging and other climatic observation. It can be seen in Table 6.4 that all RGS expenditure amounts to only 4.5 per cent of total spending and Barmby a further 3.5 per cent.

To the extent that expenditure is related to specific facilities with well defined locations, the associated costs can be allocated to a level in the hierarchy below the region. Thus, some spending on RGSs is attributable to catchments and in principle, at least part could be allocated to particular uses and possibly individual users; notably in cases where the station is needed to control a particular abstraction. Nevertheless, it appears most likely that in the majority of cases river gauging will serve all river uses in common. Its costs would therefore be considered common at catchment level and will need to be allocated in some way among subordinate units.

Rainfall and other climatic observation is potentially more complex, in that there may be some difficulty in determining whether activity relates only to surface or ground water, or at a lower level in the hierarchy to a specific catchment or aquifer. Although it is clear that such issues must so far as possible be resolved,

	£	£	%
Revenue Expenditure	1,901,973.38		
Income	438.55		
	----------	1,902,411.93	100.00
ALLOCABLE			
To Individual Staff			
TS - Resource Planning	552,124.11		
	----------	552,124.11	29.02
To Region			
Planning and Liaison	11,822.52		
Support Functions Allocation	393,418.21		
Policy, Management and Admin	383,294.18		
	----------	788,534.91	41.45
To Water Resources Management			
Rainfall Observation - General	4,621.91		
Individual Rainfall Stations	401.07		
Climate Observation - General	2,941.35		
Individual Climate Stations	977.67		
Inst. Hydrology Drought Report	2,551.00		
	--------	11,493.00	0.60
To Groundwater Users			
Investigation Instrumentation	1,613.00		
Groundwater Observ'n Network	5,612.63		
GW Mangmnt - Licensg - General	485.55		
Groundwater - Miscellaneous	1,611.11		
Observ'n - Borehole Maintnance	10,724.09		
TS - Aquifer Management	1,525.23		
	---------	21,571.61	1.13
To Particular Aquifers			
Individual Groundwater Statns	3,028.17		
	--------	3,028.17	0.16
To Surface Water Users			
General RGS Expenditure	39,013.71		
	---------	39,013.71	2.05
To Particular Catchments			
Upper Ouse Augmentation	4,313.48		
Individual RGS Expenditure	48,595.22		
Barmby Barrage	66,377.31		
	---------	119,286.01	6.27
To Individual Abstractors			
TS - Water Management Licensng	2,722.36		
	--------	2,722.36	0.14
To Individual Assets			
Current Cost Depreciation	357,390.19		
Vodaphone	7,232.86		
Leasing Charges	15.00		
	----------	364,638.05	19.17
		==========	======
		1,902,411.93	100.00
		==========	======

Notes:

TS Technical Services
RGS River Gauging Station

Table 6.4 Yorkshire Region Revenue Expenditure 1990-91 (Current Water Resources Account Data Only) at worst it is fairly safe to assume that the activity can be allocated down to the level of Water Resources Management and subsequently treated as a source of common costs.

In all these cases many of the limitations arise from the present system of accounting which, given the existing method of price determination, has not been required to identify the motivation for activity and hence expenditures. A detailed analysis of climatic observation activity would resolve many of the uncertainties and may permit the attribution of activity to much lower levels in the hierarchy. Nevertheless, it can be seen from Table 6.4 that some Water Resources expenditure can be allocated with greater precision.

Some expenditure is clearly for the benefit of groundwater users rather than surface abstractors and in the first instance, can be allocated at level 4 in the hierarchy. Even if no greater precision is possible, there is certainly no reason to attribute this expenditure to users of surface-water. Where expenditure is committed in connection with an individual borehole, it should be possible to attribute it to a particular abstractor. Similarly, expenditure connected with augmentation is at least catchment specific.

The costs of operating the system of licensing individual abstractors is also specific to the abstractor once a licence has been granted. However, a more interesting situation arises in the case of expenditure linked to an application for a licence. Here, to the extent that licences are used to control access and prevent over abstraction, the costs may be common to existing licence holders in a catchment.

Expenditure at the Barmby barrage is also clearly attributable at catchment level, even though activity cannot be identified and attributed among potential river uses and individual end users. To illustrate the sort of calculation that can be done with the data available, as a first approximation it might be assumed that the beneficiaries are users located on the Derwent below the major water company abstraction point at Elvington some 15 miles upstream of the barrage. The greatest benefits appear to be gained by the WSC, abstracting a short distance above the barrage. Consideration of the abstraction licence register gives the following results:

ABSTRACTORS	LICENSED QUANTITY tcma	SHARE (%)	IMPLIED COST (£)	ACTUALLY PAID (£)	SHARE (%)
SPRAY IRRIGATORS	904.7	20.36	13,514.42	2,982.63	22.16
OTHERS	499.2	11.23	7,454.17	457.23	3.40
WSC	3040.0	68.41	45,408.72	10,016.80	74.44
	4444.0	100	66,377.31	13,456.66	100

Table 6.5

These figures do not include benefits accruing to in situ users, flood defence or consideration of "The River". If the calculated values are a true reflection of the opportunity costs and benefits to the users, then the economic costs of operating the barrage far exceed the benefits in abstraction. It is clear that the implied benefits beyond abstraction (to in situ users, flood defence and "The River") are large. Moreover, the data excludes the rental value of capital inputs. As a rough guide, it might be noted that adding current cost depreciation alone adds at least another £40,000 per year to the cost side.

Although some costs can be allocated, over 70% of current costs are due to the activities of individual staff (some 30%) and support functions, which are much less easily allocated. In the case of staff it should be possible, at least in principle, to identify the nature and purpose of their activity and attribute it largely at the level of the end-user. In the case of hourly-paid staff who fill in time-sheets this is probably fairly straightforward, but it becomes more difficult in the case of managers responsible for a range of activities. Support functions may also be specific, although it is clear that at least a small proportion of regional administration will be genuinely common to all activity. A larger part of national headquarters activity, but not necessarily all, will also be common to the system as a whole. However, these expenditures are excluded from Table 6.4.

(b) Capital Account

The final few rows of Table 6.4 identify costs which can be allocated to individual capital assets in the region. Following the arguments outlined in Section 6.2 these figures are not regarded as an unsatisfactory treatment, except in the case of leased assets, where the charges may be treated as current costs. Where assets are owned outright, it is the rental value of the services of the asset which are relevant for pricing cost attribution and pricing purposes. Current cost depreciation, calculated for accounting purposes will generally yield a poor approximation of the value of the services derived.

Capital assets belonging to the NRA's Yorkshire region amounted to some £11.25 million at current net replacement cost in August 1991 (£15.5 million at gross replacement cost); simple linear depreciation of these assets over their remaining lives gives the annual cost of £360,000 shown in the table. As in the case of current account account transactions, certain assets are employed in general activity, but most are at least catchment specific or are employed in activities which on more detailed analysis may be attributed to specific users. An example of the last case might be vehicles.

The Barmby barrage is the only sizeable single asset in NRA hands, accounting for £2.5 million, while the recent developments in the Vale of York account (collectively) for another £1 million. The rental value of these assets is obviously attributable, at least at catchment or aquifer level. Of the assets remaining, valued at less than £8 million, the overwhelming majority are RGSs and of the £1.12 million of capital expenditure committed in 1991/92, some £660,000 is for the development of Skelton RGS on the river Ouse alone. These findings underline the extent to which NRA activity is dependent on assets transferred to the WSCs on privatisation. Clearly, the true costs of NRA activity can only be calculated with authority when the rental value of certain assets of the companies are also considered. Some tentative inquiries to Yorkshire Water PLC produced the strong impression that they were unlikely to cooperate in providing the necessary data to take this aspect of the research any further.

6.5 Allocation of Common Costs

By definition, common costs at any level in the hierarchy of activity cannot and ideally would not be allocated among particular services and hence users. As might be expected, where allocation has been attempted it has proved a source of considerable problems. Brown and Sibley (1986), for example, note that the allocation of common costs is "the source of many of the most muddled, lengthy and unsatisfactory proceedings in regulatory history". Nevertheless, allocation is often necessary in practice, due to the regulatory regime under which most industries with substantial common costs operate.

Such regulatory regimes typically impose a constraint on prices or profits, so that the existence of common costs results in a conflict between prices which induce allocative efficiency and satisfaction of the regulatory constraint. If the NRA were released from the requirement of the Water Act that it break even taking year on year, then common costs need not be recovered and prices could be established with regard to attributable costs alone. However, as remarked earlier, only a small proportion of NRA costs may be uniquely attributable to particular users, leaving a substantial shortfall in revenue relative to costs, which is unlikely to be politically acceptable.

If it is assumed that the break-even constraint is to remain in place, then prices must recover costs, with the objective becoming one of minimising the distortionary effects of the constraint. One possibility which has considerable merit from a theoretical point of view is Ramsey pricing. The essence of this approach is that because prices cannot be set efficiently, the deviation from marginal cost should be inversely related to the price elasticity of demand. A larger share of the common costs at each level in the hierarchy would therefore be borne by services where demand is less responsive to changes in price. The principal obstacle to implementation of this approach is practical, in that the necessary demand elasticity data is not readily available. It can also have considerable equity implications, in that the high price rises may fall disproportionately on low income users who have no alternative supply option.

Thus common costs will generally have to be dealt with in some other way. The practical development of alternative methods has mainly taken place in the United States, where regulated enterprises have long operated subject to a profit constraint (of which break-even is a special case). There is a large variety of methods available, ranging from the rule of thumb to the highly esoteric, but they can be broadly divided into two main groups.

The first, and more pragmatic, group start from the existence of already identified common costs and seek to allocate them as well as possible among users. At the simpler end of this category are the Fully Distributed Cost (FDC) methods adopted by many regulated utilities. In these, having as far as possible attributed costs to specific services, a simple rule is adopted to divide the common costs among that set of services. A crude egalitarian rule might simply be to divide common costs equally among the services. More frequently allocations are made using criteria such as shares in total output, peak demand, revenue or attributable costs. An equal division, in particular, might even be levied as some form of standing or fixed charge, as this would reduce the distortion caused by the marginal price deviating from the efficient (marginal cost) one.

How good the results are will vary from case to case. On the one hand it can be shown that in terms of the efficiency of resource allocation, the prices obtained using an FDC approach may be little worse than the theoretically optimal Ramsey prices. Conversely it is also possible for some users to face charges which exceed the costs of providing the service on a stand-alone basis: that is they would do better to withdraw and set up their own supply operation (this is further discussed below).

More generally it is the arbitrariness of the choice of criterion that economists dislike about FDC methods: different choices will yield different outcomes without any good economic reason to prefer one more than another. The Separable Costs Remaining Benefits (SCRB) approach is one way of trying to get around this problem: the common costs are allocated to each service according to its surplus of benefits over already determined costs. The logic of this approach is that users of those services receiving the greatest benefit, net of attributable costs, are required to offset a greater proportion of the common cost. It also has the advantage that services with no attributable costs will contribute to common costs, which they do not under simple FDC methods. However the limitation of the SCRB approach is again a practical one: that of establishing the value of the benefits derived from each service.

One possibility to determine these benefits is to consider the cost that the service would have to pay if it stood alone, although this becomes problematical if the stand-alone costs are very much larger than the actual cost. (This argument is further developed by Moriarity (1975).) This leads on to the second group of methods for dealing with common costs, which all revolve around the idea of some sort of game in which the different services are players deciding rationally whether to join in with the central organisation or to operate independently. The key point is that, given the existence of common costs, lower overall costs will be achieved by conducting the activities required in a single organisation. Prices should therefore be set (and common costs allocated) so as to ensure that users are indeed willing to obtain the service from the central organisation, rather than make alternative arrangements, either as individuals or in coalitions with other users and services.

One thing this requires is prices that avoid cross-subsidy, the logic being that consumers will object if the allocation of common costs involves one service subsidising another. Subsidy-free prices may then be specified as those which satisfy the rationality principle, that is that they do not exceed the cost of obtaining the service by the best alternative means (note that 'subsidy-free' here means free of paying a subsidy, not necessarily of receiving one). Using this argument the SCRB approach would mean that cost saving benefits are allocated in proportion to the marginal benefit (cost saving) due to the inclusion of the service in the project. This property is also consistent with stability of the co-operative arrangement, in that it minimises the propensity to disrupt. (See Loughlin (1977) for a further refinement of this approach involving weighted benefits.)

A variant of the SCRB method which takes explicit account of the alternative cost of obtaining a service is the Non-Separable Cost Gap (NSCG). In this formulation each user will have in mind a concession, the margin over separable cost which he would pay under the best alternative conditions. Under NSCG the non-separable (common) costs of centralised provision are divided among services in proportion to their share in the value of total concessions.

What these approaches are trying to do is to identify the range of prices which satisfy both the profit constraint and the rationality requirement (both individual and collective) for subsidy-free pricing. The upper bound is formed by the stand-alone cost, as going above this would clearly drive a group of consumers away; at the other end of the scale, no group of consumers pays less than the incremental cost of service associated with it. All such prices are said to be contained within the core. Unfortunately, under some cost conditions there may be no solution in the core, whereas in others there may be many. In the first case, the imposition of the constraint is clearly infeasible, if prices are to be subsidy free, while in the second, we have a problem in selecting a particular solution. The approaches discussed so far, including the SCRB methods, may all result in prices which are not in the core.

There are several other solutions within the core suggested by game theory which are not discussed here in detail. One is the Shapley value, which is an assessment of the expected cost of adding a new service to a project. Another solution proposed is the nucleolus which is as far away from the boundaries of the core as possible. This can be shown to maximise the minimum savings derived from centralisation, and can also be adjusted for the size of the coalition. Finally, the notion of the core may be integrated with the sort of mechanistic allocation rules discussed earlier.

A more recent development is the axiomatic approach, in which the required properties of an allocation are specified to start with, leading to the derivation of appropriate price structures. (Solutions in the core could be regarded as outcomes derived from an axiomatic approach.) Typical axioms require that relative prices reflect relative costs and that price solutions are not dependent on the particular formulation of the problem. In some circumstances this approach may lead to pricing schemes in which common costs are allocated as an "add-on" and allocated in proportion to the share in attributable costs, resulting in prices not unlike those obtained using a fully distributed cost approach. As we saw earlier, it is unlikely that the resulting prices will lead to allocative efficiency.

6.6 Conclusion

This section reviews some of the key points from the main body of this chapter, and finally enumerates our recommendations.

It has been argued elsewhere in this Report that it is important that prices send the correct signals to consumers. To do this they must reflect the costs of supplying particular services, but at present the NRA does not have the necessary information on what these costs are. The main purpose of this chapter has been to set out a methodology which the NRA should adopt in its cost allocation. The detailed recommendations as to how the NRA should proceed are gathered together at the end of this section. We are aware that our proposals entail considerable changes in both the Authority's accounting systems and the thinking behind them, but we consider it essential that these changes are made.

6.6.1 The Present Position

The introduction to this chapter contrasted the way the break-even requirement imposed on the Authority has led to average cost prices with the economic arguments for marginal cost pricing. Full marginal cost pricing will undoubtedly not be practical, but the NRA has been encouraged to adopt an approach where prices are seen to be clearly related to <u>attributable costs</u>. Thus the "specific objective" of the chapter was to "seek a cost allocation methodology capable of identifying the relative costs of abstraction opportunities".

As a starting point for this, Section 2 considered the work of the NRA's own Water Abstraction Charges Project (WACP) Team. These are a valuable beginning, and made good use of the available data (our own attempts to use the existing data system made little further progress), but equally their shortcomings serve to highlight the inadequacies of that data. In the first place data limitations forced the WACP to adopt a total expenditure approach and neglect the distinction between capital and current expenditure. The results of our own attempt to pursue this question further are summarised in Table 6.1 and Figures 6.1 and 6.2. The fact that even such basic information as the division between revenue and capital expenditure was unavailable in most regions emphasises the inadequacy of the present accounting systems for pricing purposes.

Secondly the WACP work covered only activity currently included in the water resources account. The present study led to the conclusion that, for the purposes of cost attribution, the NRA's present division into core functions is inappropriate; remedying this forms the basis of one of our main recommendations. A related point is that the present system does not acknowledge the existence of common costs, which are a particularly important characteristic of the Authority's activity.

Problems were also noted in the NRA's processes of funding capital expenditure, which although once standard practice in the public sector have major drawbacks. They include the imposition of an arbitrary budget constraint, due to the funding of capital spending from current revenue rather than access to the capital market. A further requirement is the need to account for certain capital assets which are in the hands of the water companies, but contribute to water resources management. They should therefore be included in any calculations of the economic costs of the NRA's activities. For practical purposes the ownership of these assets is pre-determined, although there remains a cogent argument for their being transferred into the hands of the NRA. Irrespective of the ownership of assets it is the rental price of capital which is the relevant concept for cost attribution and pricing.

6.6.2 Proposals for Change

We propose a departure from present NRA practice in two respects in particular. First, the river should be viewed as a specific purpose to which activity may be directed, including the pursuit of environmental benefits. Such activity should be accounted for, even though, like in situ use, it is not generally charged for now and may well never be in the future either. The second respect is the need to adopt an activity analysis approach in the context of service provision. The question that needs to be asked at all times is what motivates activity; as was said earlier, "implementation of a scheme of charges based on economic costs requires an operationally relevant breakdown of NRA (and some PWS sector) activity" (page 00). Our key recommendation is the need to develop more detailed accounting systems consistent with the activity analysis just referred to.

This type of cost analysis has not been very widespread in service industries. The approach we recommend is similar to that put forward by Dearden (1978), and is based on the idea of a hierarchy of activities. This method starts from the highest level within the organisation and identifies activity on a causative basis among subordinate levels; this is applied iteratively until the lowest level is reached. Costs not attributable to a particular lower level are common to all subordinate activities. Experience in the United States suggests that a high proportion of costs can be attributed, given the necessary accounting systems.

Although the approach is not new, we believe that it is the most suitable for the NRA's purposes and that it can be implemented in practice, although this will require major extensions of the accounting system used by the Authority. Figure

6.3 above gives the hierarchy we propose for the NRA. Although it is strongly influenced by our case-study of the Yorkshire region, we believe it is sufficiently general, and in any case can be readily adapted tospecific regional conditions.

6.6.3 Allocating Costs

Despite the comments above about the quality of the available data, the Dearden methodology has been applied to the Yorkshire region; the results are summarised in Table 6.4 above. The figures shown there go a little further than those of the WACP team, and do at least provide an illustration of the sort of reasoning that is needed. There are however three major limitations when compared with the proposed hierarchy in Figure 3. One is the capital assets owned by Yorkshire Water PLC; the relatively few and mainly small assets owned by the NRA do not contribute a great deal to the total costs. The second is that the data we have is only for the water resources core function as currently constituted, and is therefore only a subset of the total relevant expenditure. Finally, and related to this, activity in support of the river cannot be identified.

The main practical difficulty in cost allocation exercises arises from the presence of common costs, and it is unlikely that the problem can be avoided in the NRA's case. It will not arise if the organisation is permitted to make a loss, but this is unlikely in practice. A solution advocated by economists, because of its capacity to uphold allocative efficiency, is Ramsey pricing. However this requires detailed information about consumer demand which is unlikely to be available. Thus common costs will have to be dealt with in some other way. The variety of methods presently available can be divided into two main categories.

Among the simpler techniques are the Fully Distributed Cost (FDC) methods, where the common costs are distributed according to some rule of thumb; this might be relative output or directly attributed costs, or could just be an equal share of the total to each user. However such rules are essentially arbitrary: different choices will yield different outcomes with no obviously 'correct' answer. One solution is the Separable Costs Remaining Benefits approach, in which the common costs are allocated to each service according to its surplus of benefits over already determined costs. This of course means that the benefit has to be measured, which may generate its own problems.

he second group of methods depend upon the idea of subsidy-free prices. Centralisation of the provision of services will generally yield lower total costs, so an allocation of common costs must not drive away additional (groups of) customers who are willing to pay at least their directly attributable costs. Equally no service will be prepared to pay more than it would have to as a stand alone operation. Thus limits are established on the share of common costs that can be levied on a particular service.

On the basis of the analysis conducted to date, a strong case can be made for subsidy-free solutions, subject to the problems (and costs) of obtaining and updating the necessary information. In the light of our study we doubt whether this would be practicable. A workable solution given present information would be some form of the FDC approach. Over the longer term we would favour the SCRB approach, although this requires information on alternative costs of provision.

6.6.4 Recommendations

The following are our conclusions to the NRA on action to be taken:

1. The present financial accounting structure is not intended as a basisfor cost attribution and cost-based pricing. We recommend the adoption of an accounting system consistent with detailed analysis of NRA activity.

2. The present division into seven core functions was found to be inappropriate for cost attribution and we recommend the use of a hierarchy of the sort shown in Figure 6.3 above.

3. Effective cost allocation exercises require greater precision in the recording of the motivation for, and allocation of resources to, particular activities. In the case of the NRA the highest priority is the monitoring of the use of staff time.

4. Taking ownership of the infrastructure as given, there is a need for greater flexibility in the operation of reservoirs and compensation flows. In particular we believe that the development of a market-like relationship between the NRA and the water companies in this respect would prove more flexible and obviate the present need for parliamentary action when both parties are in agreement.

5. Common costs are characteristic of NRA activity, and a mechanism is needed to allocate them. In the longer term as the necessary information becomes available we propose the use of the SCRB method; in the interim an FDC method may be adopted.

7. BEHAVIOURAL, PRACTICAL AND POLITICAL CONSTRAINTS

7.1 Introduction

In the previous chapter it was stressed that there are key difficulties involved in devising an 'optimal' cost attribution system. It is nevertheless possible to improve significantly current cost allocation procedures, without incurring major additional administrative costs. Armed with improved cost of service information, the NRA will be in a position to implement some form of cost based pricing system, with tariff structures revised as suggested in Chapter 2. While any implementable pricing scheme will undoubtedly fall far short of the theoretical ideal, cost based prices have the potential to markedly increase the efficiency with which water resources are allocated. However, their effectiveness will critically depend on the way abstractors respond in practice to the charges. Moreover, the feasibility of introducing particular incentive based pricing or permit trading schemes will be affected by both the likely distributive consequences and the extent to which improvements in allocative efficiency conflict with the achievement of other NRA objectives. These potential behavioural, practical and political constraints on the use of economic tools will be considered in this chapter.

It is well known that an optimal pricing system will only produce an efficient allocation of water resources under specific conditions. In the context of this appraisal of the potential role of economic tools, two of these conditions have particular importance. First, water abstractors need to be rational 'economic men', aiming to maximize their profits over time and with the knowledge and ability to do so. Second, abstractors will need to be operating in competitive market conditions, with insufficient monopoly power to simply pass on any water cost rises in increased product prices. While real world conditions always deviate from the economic ideal, the extent to which actual behaviour and market conditions approximate to the economic man and perfect competition postulates will have a major influence on the outcomes of water pricing policies. However, it must be stressed that in the abstraction water case any observed, apparently non-rational behaviour may simply reflect the fact that prices have typically been too low to have much relevance in production decision making.

In the first part of the chapter attention is focussed on the likely response of individual manufacturing companies and farmers to cost-based pricing and permit trading. Four related questions will be addressed. First, to what extent are there informational, behavioural, organisational and financial constraints operating to inhibit private abstractors from responding to economic signals in the desired economically rational manner? Second, under assumptions of 'optimal' and likely actual behaviour, what impact will cost-based pricing have on the demand for abstraction water over the short and long-term? Third, what implications arise from abstractor response to price for NRA pricing policies, demand management objectives and investment programmes? And finally, where capacity extension is not feasible or meaningful prices are difficult to establish, would permit trading be an acceptable, more easily implemented and effective method of demand management than rationing by unit price?

The potential behaviour of the water companies and their customers will be addressed separately in Section 7.5. Their leakage control, capacity development and pricing policies will clearly have an important influence on the effectiveness of the NRA's attempts to employ economic tools to control the demand for and to allocate abstraction water; in addition the potential reaction of the economic regulator will also be of relevance.

Finally, in the chapter an attempt will be made to discuss the likely economic and social consequences of any re-distribution of available abstraction supplies and to identify the potential conflicts between improved efficiency in resource allocation and other NRA objectives.

7.2 The Behaviour of Private Abstractors

7.2.1 Imperfect Awareness and Information

An obvious pre-condition for a rational response to price is that abstractors are aware of the prices paid, their consumption levels, the possible water saving options and the costs involved in adopting these. Almost 21% of the irrigators questioned in the farm survey were unable to recall their licence conditions and apparently did not understand the way their abstraction charges varied with season. However, with relatively few exceptions most irrigators had reasonable knowledge about the availability and cost of more water efficient technologies and about less water sensitive crop mixes. Although clearly at present the one-fifth of farmers with imperfect price information cannot be expected to react rationally to current price signals, in general irrigators were water aware and the expectation is that at cost-based price levels they would respond in a rational manner; however, this need not mean that profit maximization (or cost minimization) will be the objectives behind such rational responses (see 7.2.2).

The picture which emerged from the survey of industrial abstractors was rather different. Twenty seven percent of the interviewees claimed neither to know their total water consumption nor details about its breakdown into abstracted and mains supplies. Indeed four cases emerged where it came as a surprise to the technical manager that an abstraction licence still existed and was being paid for. Just over 30% of interviewees could not recall the prices paid for mains supply or for the NRA authorisation, while a staggering 83% of those taking supplies via the British Waterways Board were unaware of the tariff structure under which they operated, had no idea of the unit price for their actual consumption (ie the volume charge) and did not know how the returned water rebates affected their total bills. [The information was only eventually obtained by the interview team by locating an old bill]. Moreover, only a small minority of companies had any clear knowledge about water saving opportunities, recycling costs and the costs of more water efficient process technologies.

As was pointed out in Chapter 4, water was all too often an unconsidered minor element within a firm's total production cost structure. The widespread lack of interest in water saving possibilities is, of course, understandable when just abstraction charges are taken into account, but even when the use of the much higher priced mains water was considered, a similar attitude was evident. Fifty five percent of interviewees were unable to specify even in broad terms the quantity of water employed for different in-plant purposes. Only 12 firms would think about making any changes to their water using behaviour even if mains prices rose by 50%; some claimed efficiency savings were impossible, which was clearly incorrect, while the views of the rest can be typified by a remark made by the manager of a small ceramics plant "the water bill is so small, we have other problems which have to be dealt with first".

There is a strong suggestion that for the majority of manufacturers, very major (and well publicized) changes in water prices will be necessary before those responsible for water use decisions feel the need to gather the information necessary to make a 'rational' response to economic signals. One possible explanation for the generally poor awareness of water costs, associated waste water charges and the potential savings which result from recycling and other economy measures, may lie in the internal division of responsibilities within firms. In only 55% of the surveyed companies were water and effluent bills sent to, or checked by, the technical manager responsible for water use and pollution control decisions: significantly 28% of the managers were not even aware of who did receive the bills. Somewhat unexpectedly it was in the relatively small companies, employing less than 500 people and operating a single plant, where the divorce between technical and financial responsibility was most evident. The larger, and particularly multi-plant operators, were more likely to ensure that the technical staff had water (and waste-water) cost information. In 70% of the multi-plant companies the technical department either directly received the bills or were required to check all bills and authorise their payment. Interestingly a number of managers reported that the revision of accounting procedures to require bill vetting by technical staff had revealed long histories of unnecessary payments being made; these include the case of one very large multi-national where apparently payments had been made to the BWB of some £50,000 per annum for abstraction and discharge contracts which had not been required for almost 20 years. It is also worth noting that the larger multi-plant companies were the most likely to have undertaken (or be planning to undertake) some form of environmental or energy cost audit and to view their water use and disposal decisions in a wider cost saving context.

These results appear to diverge somewhat from those obtained in the OXERA/ERL (1992) study on industrial attitudes towards market mechanisms conducted for the Department of the Environment. Their study of 14 companies, all in industrial sectors associated with high levels of polluting discharges, concluded that "on the abstraction side, smaller companies clearly paid greater attention to the costs of water charges than larger ones" (p4). They also argued that all companies "paying trade effluent charges monitor their discharges carefully, and are fully conversant with the basis of the charge" (p4). While in our sample monitoring of discharges both to sewers and rivers did indeed occur, this was largely to ensure that consent conditions were met. By no means all technical managers were aware of the way the trade effluent charging schemes operated and none could say how the new NRA direct discharge payment system worked and would affect them: it should be noted, however, that most of the direct dischargers (46% of the total sample) were discharging to BWB canals and not to rivers.

One possible explanation for the difference in results could lie in the way the OXERA/ERL firm sample was selected. Not only were they all in the most polluting industry groups but "most were companies known to ERL from earlier studies from which we expected to obtain a helpful response" (p 1). It is, therefore, possible that they were picking up some of the most water/waste water aware companies, whereas our more random sample covered firms with more diverse behavioural and pollution generating characteristics.

7.2.2 Non-Profit Maximizing or Cost Minimizing Business Goals

Even when abstractors are fully aware of total water costs and water saving opportunities, they will not necessarily make their water use decisions on profit maximizing/cost minimizing criteria. It was particularly evident that for irrigation abstractors other management objectives were important. First, and foremost, many irrigators proved to value income 'certainty' and regularity above profit maximization per se. Contracts with supermarkets and food processers provide a 'guaranteed' income, reduce market risk and to an extent, marketing costs, although contract prices are rarely above and are often below those achievable on the open market. The quality specifications contained in these contracts commonly necessitate irrigation, and indeed there is now evidence that some contractors are specifying the availability of irrigation as a condition of contract. As was noted in Chapter 3, in the very short term (ie during the growing season) irrigation demand appears highly unresponsive to price: the existence of contracts and the search for income security, means hat even in the medium term irrigators may not respond greatly to water price rises.

Second, but also related to the risk averse nature of many irrigators, some farmers aimed for production flexibility, keeping future crop mix options open and diversifying current output (and thus income sources). Irrigation was, therefore, regarded as a form of insurance policy against normal market risks and potential changes in agricultural policy. Once again, the effect is to reduce the responsiveness of farmers to water price rises and increases the tendency to retain currently under (or un-) utilized licences. Third, some irrigators were not only concerned with the value of production gained by irrigation, but were conscious of the effect of an abstraction licence on the value of their main asset - the land itself. This feature clearly complicates the potential response to prices for authorisation and suggests that permit trading, which separates water rights from land values, could have an important role to play in the re-allocation of abstraction supplies. Finally, it is perhaps worth noting that at present a very small group of farmers are employing their abstraction licences for environmental and farm tourism reasons to maintain ponds, fishing lakes and water bird habitats.

In the industrial sector it was less easy to get interviewees to articulate explicitly their non-efficiency related management goals which could affect water use decisions. Nevertheless it was evident that such goals existed. In the first place, there was a strong "its not worth the effort" or "water is the least of my problems" school of thought. A number of technical managers reported that, particularly in the current economic climate, they had enough problems keeping the production system going, with inadequate resources for equipment maintenance and replacement, to even consider re-appraising current water use practices.

Secondly, but closely related, was the "if its not broken don't fix it" approach. Although there were clear exceptions, many interviewees simply did not think in cost minimization terms, past changes and planned future adjustments to water use and disposal occurred in response to some technical crisis or new legal requirement rather than for cost saving reasons. A variety of technical problems were cited - greater fluctuations in the hardness of mains water, deterioration in canal water quality, new equipment which is more water quality sensitive, existing water quality inadequate for new product range - which had prompted a review of water use. At this stage, water cost savings would be considered but as a 'bonus', an offshoot from the solution of the technical difficulties themselves. In the same way, meeting environmental regulations or solving perceived environmental health problems were frequently seen as more important than water supply and disposal cost savings. For example, one company spent £2.5 million on a dry dust suppression system, major reductions in water use occurred, but the motive was to meet new E.E.C. standards..

Such 'non-efficient' management behaviour suggests that the short-term response to even quite major unit water price increases is likely to be small. However, in the longer term when equipment or process changes occur for other reasons, then water supply costs, energy savings and disposal costs will together tend to increase water use efficiency. If the figures presented in our case studies (Section 4.5.3) of the per unit cost of water saving technologies are in any way typical, then the long-term elasticity of industrial demand for water should be high when the total costs of supply and disposal are taken into account. It is essential that in any attempt to forecast likely future industrial demands that water costs are viewed holistically to include the unit cost of waste water disposal. This is already crucial where discharges are made to sewers, where some firms in our sample were reporting per unit disposal costs up to five times greater than mains water supply costs. The NRA's new cost recovery charge scheme could also have a long-term impact on abstraction decisions, particularly given the volume bands and the insensitivity of the pollution content bands to increased load concentrations. Clearly, the charges will generally be too low to affect consumption in the short-term, but the expectation must be that firms when making future investment decisions will seek to move to a lower volume factor band, but will have no incentive to reduce the pollutant load itself. This could have important implications for the 'demand' for in-situ dilution supplies

7.2.3 Capital Constraints

The speed with which irrigators and industrialists respond to water cost/price changes will critically depend upon the availability and cost of investment capital and on competing investment opportunities. Likewise (and particularly relevant for irrigators) the rate at which currently un-economic water uses are abandoned will be affected by the life of existing fixed capital assets. Further, the potential for the adoption of water saving technologies can be affected by the nature of the basic capital asset, namely the factory or farm site. In other words capital, both investment finance and fixed, plays an important but often neglected role in determining the short to medium term effectiveness of economic demand management tools.

As shown in Chapter 3, the annualised cost of storage was generally low when compared to the gross margins achieved by irrigation over the dry farmed wheat option. Moreover, storage was frequently the lowest cost response to unreliable or inadequate summer abstraction. If it can be assumed that future storage costs will not diverge markedly from those experienced in the past and that the gross margins achieved by irrigation will also remain broadly constant, then an extension of on-farm storage is already an economically viable proposition for some irrigators. It will become even more so if the NRA revise their charges for summer only and the summer portion of all year licences, or make more frequent use of summer abstraction bans. However, long-term viability does not necessarily mean that investments will take place. A recurring theme was that existing levels of debt, the problems of raising capital from the banks and uncertainty about interest rates restricted farmers' willingness to undertake capital investment. Moreover, if investment funds could be made available, then additional water storage was merely one out of several potentially revenue raising or cost-reducing options (improved grading and packaging equipment, diversification into leisure facilities etc). Further, some farmers rejected investment in storage because it was a risk (see 3.9.5); they were seemingly more prepared to bear weather related revenue losses than spend capital on their minimization. This finding is consistent with much of the North American work on response to natural hazards; loss bearing because of an "Act of God" was more acceptable than a loss resulting from a 'mistaken' conscious choice to change operating practices. As there is only a limited market for second-hand irrigation equipment and virtually none for redundant storage facilities, past investment is a sunk cost and irrigators will continue to use the facilities until net irrigation yields fail to meet even recurrent costs, including essential maintenance. This means that responses to water price rises are likely to be relatively slow except where prices for actual consumption become high enough to deter farmers from using any 'surplus' authorised supplies to irrigate very low margin crops.

Capital constraints were equally pertinent for industrial abstractors. The majority (64%) of sampled firms currently have no recycling facilities at all; of these 32 (also 64%) claimed that restricted capital availability would prevent investment in re-use even if over the longer term reduced energy, water supply and disposal costs made it a viable proposition. Typically the surveyed companies required any capital investment to achieve pay back within 3 years, and one manager reported that any capital expenditure he made had to be paid back in 1 year; under these circumstances any capital intensive cost reducing measures are highly unlikely to be undertaken. Another investment related point frequently made was that if conservation efforts were to be made, conservation of energy would take precedence in the competition for funds over water/waste water savings. Likewise, particularly in small companies, it was clear that, when an economic upturn occurred, investment in water economy per se would be very low on the list of 'essential' new equipment, priority would go to investments which increased output levels or product quality or which 'modernised' existing processes. Water savings per unit product could be a by-product of such improvements but not their objective. Finally, it was pointed out that fixed capital constraints would also inhibit responses to increased water/waste water charges; space constraints, the need to overhall plant layout and the knock-on effects of any change in water quality were the most frequently cited reasons for adhering to existing water use systems rather than moving to an apparently lower cost option. Once again these different forms of capital constraints must act to limit the short-run effect on abstraction water demand of even quite major price rises.

7.3 Implications of Abstractor Response for NRA Policy

It has frequently been assumed that the value in use of water for irrigation is relatively low and that at higher price levels the aggregate demand for water is elastic. However, the farm survey results (Section 3.5.2) suggest that for the crops typically irrigated in the Anglian Region use values can be very high in the short-run (ie once capital has been sunk in irrigation provision). This general statement does not, of course, imply that all farms and all irrigated crops exhibit the same high values. The evidence appears to indicate that the majority of irrigators' , are on the steep section of the 'kinked' demand curve, illustrated in Figure 3.1, Section 3.2. Since irrigators with similar crop mix characteristics tend to be clustered, it is feasible to suggest that within particular catchments this kinked curve applies to the aggregate as well as individual farm demand curves. The implication must be that under the assumption that irrigators are rational profit maximizers their overall demand for abstraction supplies will not be significantly affected in the short run by increasing prices for authorisations or actual water use. This 'rational' response to price is further re-inforced by the way irrigation helps fulfill the 'non-optimal' revenue stability and risk minimization objectives discussed in 7.2 above.

However, the limited short-run demand elasticity for total water abstraction does not mean that the NRA has no scope for charging the costs such abstraction imposes on the water resources system as a whole. On farm water storage is normally, but of course not universally, relatively low cost. It should, therefore, be possible for a switch to be made in the timing of abstraction, without significantly affecting the viability of irrigation. In other words while total demand elasticity is minimal in the short term the elasticity of time of use demand need not be unresponsive to price. Properly constructed cost related charges could have an important role to play in affecting such a switch by substantially increasing the price differential between winter and summer abstraction. Under most conditions winter abstraction prices per unit authorised, when calculated on a marginal opportunity cost basis, will be at, or close to zero (there would still be a flat rate administration fee - standing charge). All summer abstraction prices, including those payable by all year round licence holders, would escalate to cover the long run marginal cost of capacity expansion (theauthorisation based charges) and additonal per unit volume charges could also be levied as 'drought' surcharges or demand rationing devices. Rational irrigators attempting to profit maximize should respond to the increased price differential by extending or installing on-farm storage. However, as already discussed capital availability constraints could be a major response inhibitor. To help overcome this problem and to increase the speed with which irrigators move away from peak summer abstraction, the possibility of instituting storage development loans should be investigated.

Our evidence suggests, albeit based on only a limited sample of farms, that storage costs, while varrying between farm businesses, were relatively low in relation to the margins generated by the irrigation of high value crops. Where on farm storage is cheaper than the cost to the NRA of increasing summer water availability and reliability, there is no economic justification for the NRA to embark on supply augmentation. However, it has to be recognised that shifting the effective cost of summer supply enhancement onto the farmers themselves has distributive consequences. Under current arrangements if the NRA undertakes the augmentation the costs are spread across all abstractors in a region. In addition, if a high proportion of irrigators move to very low priced winter only abstraction then there are clear implications for NRA revenue generation. It is important, therefore, that attempts to shift the timing of abstraction to take place within the context of a comprehensive review of tariffs, and cost allocation procedures.

In the longer term, total irrigation demand is likely to be more responsive to price but there are still important barriers to the achievement of a theoretically optimal resource allocation using price alone. As indicated in Section 3.5 in 33% of the surveyed farms for which good capital cost data were available, irrigation was uneconomic; if such farmers behaved 'rationally' they would not replace existing irrigation facilities and would move to dry farming. Clearly the proportion of non-viable irrigation enterprises will increase if abstraction charges rose significantly in real terms, but will decrease if the real net price differential between irrigated crops and wheat rises. However, as has already been seen, there are important risk reducing reasons why farmers may retain the potential to irrigate even though on profit maximizing criteria it is not economic to do so. Risk reduction is, of course, a legitimate business objective and as long as the farmers concerned are willing to pay the full opportunity costs of retaining their licence as an insurance policy, there is no economic justification for re-allocating their supplies to apparently higher value uses.

Where 'un-economic' licences are held because of their impact on land values, then changes to NRA policy could release supplies for higher value uses. At present the NRA is inadvertently creating and destroying land value premiums; creating them by restricting the issue of new licences and undertaking reliability or availability enhancement programmes to benefit established right holders and destroying them by imposing usage bans (see 3.8). Theoretically, if the price of authorised supplies was set to cover long-run supply augmentation costs and the NRA was willing to issue new licences for abstractors willing to pay these costs - then land value premiums would be markedly reduced and low value in use licences would be released. Alternatively, licences (or the authorised water) could be traded separately from the land (see below), an approach which would in any case be necessary to tackle situations where supply augmentation is not possible and the problem is to improve the allocation of a limited resource base.

In general we conclude that economically based unit pricing has a role to play in influencing irrigation demands for abstraction particularly in the short to medium term to change the time of abstraction and in the long-term to reduce absolute demands. On the other hand, our evidence strongly suggests that increased abstraction charges alone will have minimal impact on industrial water use behaviour in the short and medium terms. Short run demands appear to be almost totally unresponsive to price. Over time when product changes, process adjustments or investment in new plant takes place, water supply costs will be viewed as part of the package of water associated costs, including heat savings and reduced waste water disposal, which influence the choice of technology. This does not imply that industrial abstraction charges should not be cost based but it does mean that such charges will be slow to improve allocative efficiency and that price will be a poor tool to employ to achieve demand rationing to overcome speedily any drought or over-abstraction problems. From our admittedly small sample of industrial abstractors, the suspicion is that physical supply restrictions or other rules and regulations (for example, requiring water recycling to be installed) will have a more immediate influence on behaviour than would price; new restrictions or rules pose technical 'crises' which have to be solved. The evidence obtained from manufacturers on the value in use of water was very limited, however, it appears likely that the value of 'once through' supply is low. Our case studies demonstrated that annualized recycling costs (even using a three year capital cost repayment period) can be small, particularly when savings on trade effluent charges and energy are taken into account. If these costs have any general applicability then the NRA would rarely be justified in augmenting supplies to allow 'once through' industrial use.

7.4 Tradeable Permits

Tradeable permits are only a useful allocative device if a resource is scarce, new allocations are unavailable and established use rights acquire scarcity value. This implies that in our study areas, there is little scope to employ marketable rights as a device to improve the efficiency with which industrial abstraction water is distributed. Even in the over-abstracted Cam and Rhee manufacturers were not aware of scarcity, supply reliability was a non-issue and no evidence could be obtained that an abstraction licence added value to industrial sites. In the Severn-Trent and Colne Catchments, there was a similar, but more understandable, disregard for scarcity; canal abstraction licences were seen to be easily obtainable, as were ground water licences in the Birmingham region, while in the Colne industrial contraction and restructuring were seen as forcing releasing abstracted supplies. Although in Rees (19??) there was some evidence that restricted licence availability was creating authorisation value in the catchments around London (Colne and Lea, for example) it seems likely, under current economic conditions and with changes in the composition of industrial activity, that even in these areas the scope for permit trading will be limited.

When industrialists in our sample were asked to express their attitudes towards the introduction of tradeable permits, the reaction can only be regarded as cautious. Only 32% saw it as a potentially useful development, and interestingly all but 5% of these were multi-plant operators. The vast majority of single plant, owner managed companies either had no knowledge of permit trades as an allocative device, or regarded trading with suspicion, fearing it would operate to 'rob' them of their 'entitlement'.

There appears to be more scope to employ permit trading to re-allocate available supplies between irrigators. While it is recognised that restricting trades to one abstractor group has potential efficiency disadvantages, it should reduce acceptability problems and reduce the social costs involved in community or sector run down. Moreover, we have no evidence that manufacturers will be interested in joining an established trading system, although of course, it is possible that new firms or those previously denied licences would take part. One obvious reason for considering trading in the first place within the context of irrigation abstraction, is the fact that licences are known to confirm significant value premiums on irrigable land. There is, therefore, already a potential market for licences. Some of our surveyed farms were already involved in land plus water leasing arrangements with neighbours, but the tying of the licence to particular acreages greatly limited the re-allocative potential.

Over half of the sampled irrigators saw permit and/or water trading as a good development and significantly all over 400 ha 'upland' farmers were of this view. Importantly, the contacted non-abstractors all welcomed the potential opportunity to realise a valuable asset. However, this later reaction has implications for the

NRA. While trading might improve the allocation of available authorisations any movement of licences away from non-abstractors could exacerbate scarcity (the so called sleeper licence problem). Interestingly, a number of irrigators saw water trades as important in improving the way existing markets for potato and sugarbeet quotas operated. This reaction could run counter to the objective of the quota system (ie to reduce supply) since clearly farmers saw more water as a means of increasing production intensity on the quota acreage. It could also have implications for pesticide and nitrate pollution. Such knock-on effects of any trading system will need careful appraisal, trades which improve water allocations but create costs or reinforce distortions elsewhere in the economy need not be desirable. A carefully targetted experiment to establish the effectiveness and consequences of trading mechanisms would be valuable.

7.5 Water Companies and their Customers

7.5.1 Elements of Uncertainty

For the 'urban' water demand sector the potential reaction to economically based abstraction charges will critically depend on three things. First, the types of tariff operated and any new tariff structures adopted as a result of the changed signals about abstraction costs. Second, the response of final consumers to company tariffs. Third, any alterations made to current leakage control policies and practices as a result of the revised abstraction charge scheme. If water companies were perfectly competitive, profit maximizers already charging all customers on a per unit volume basis and with installed metering technology designed to operate peak tariffs, then it would be relatively, but still not very, easy to predict the potential response to marginal opportunity cost based abstraction charges. The fact that we are actually dealing with regulated monopolies, at present deriving approximately 67% of their water supply revenue from unmeasured services adds considerable complexity and uncertainty.

Still further difficulties are created because the overall impact on water company costs of 'optimal' marginal opportunity cost based abstraction charges is largely unknown, although it is clear that it will vary markedly between companies. In very basic terms cost increases would be minimal where supplies are taken from winter charged surface reservoirs, river intake points built for downstream in catchments, and where treated sewage is returned to upstream parts of a catchment. On the other hand, potentially significant cost increases could arise if raw water supplies are taken from most ground water sources, storage facilities requiring summer 'top up' abstraction, run of river intake points in upstream locations and where waste water is released to downstream todal or coastal waters. The existence of water only companies adds another complication since the discharge locations for their waste water are determined by other companies. Given the regulatory system the size of any potential total cost rises becomes important since there is a 'materiality threshold' which must be reached before cost pass through will be considered. Within the dimensions of this project, it is impossible to deal with the specifics of each company's situation, indeed we have neither the data nor resources to even attempt an approximation. Rather attention must be focussed on the way the broad economic messages conveyed in a marginal opportunity cost based abstraction charge scheme might be translated and responded to.

7.5.2 Availability or Actual Abstraction Charges

The basic purposes of an efficient abstraction charging scheme would be to influence companies to take supplies from the lowest opportunity cost sources and to curb overall demands until the value of additional supply exceeds augmentation costs. Theoretically source specific marginal cost pricing based on authorised volumes could, in the long term at least serve to fulfill these objectives. In practice, however, within existing total authorised capacity, companies operating a multi-source integrated supply network will have no incentive to switch their abstraction to the lowest opportunity cost sources unless significant charges are levied on actual consumption. Likewise authorisation charges provide no incentive for companies to increase their leakage detection efforts except where new capacity and therefore new authorisations are being sought; actual consumption charges would on the other hand exert continuous pressure on the companies to restrict network losses.

There is clearly a dilemma, which applies to all abstractor groups but is most critical in the water company case Ideally, long run marginal supply costs should be levied on authorisations payable as an availability charge to reflect the opportunity costs imposed on the resource system by 'reserving' a supply for the licence holder. However, where an abstractor is extremely unlikely to relinquish part or all of a high cost licence, only actual consumption based charges will influence their water use behaviour and in the case of the supply companies the tariffs they impose on end users. Actual unit abstraction charges set on a source specific marginal opportunity cost basis could make a substantial contribution to the NRA's efforts to curb usage of over-abstracted catchments and ground water sources. Moreover, they lessen the temptation for the companies to set marginal volume based prices which encourage water use. If urban water suppliers are operating within authorised capacity then their per unit supply costs are reduced the more water they provide to measured end users. Actual abstraction charges can of course never entirely overcome this tendency which arises because of the high fixed capital element in company cost structures. However, there are disadvantages associated with actual use pricing. Most obviously NRA revenue could vary markedly with weather conditions and any released supplies cannot be allocated to other users (except temporarily to the river itself) since the authorisation still reserves the supply. Moreover, if all charges were levied on actual consumption, there would be little incentive for companies (and other abstractors) to curb their demands for authorisations. Under these circumstances it would seem appropriate to employ some form of two element tariff with both actual and authorised usage attracting significant charges, where of course such charges are justified by the opportunity costs imposed by the abstraction on the resource system. In what follows, the assumption will be made that actual use charges are in operation. If, however, the policy of charging only on authorised quantities continues, then all that needs be said is that increased unit prices will have a minimal effect on company behaviour until new authorisations are required.

7.5.3 Charging Methods and Tariff Design

For marginal cost based abstraction charges to have an impact on urban end user demand (apart from pipeline loss reduction) quite major changes will be needed in current company charging practices. It goes without saying that domestic consumers will have to be given a metered service; at present any abstraction charge increase would simply be passed on to customers (subject to price regulation) in the form of the flat rate fees payable to obtain any water at all. Measured tariffs would then need to be restructured to convey to consumers the costs which their summer consumption imposes on the resource system. In addition where integrated supply networks are not in operation, the practice of regional price equalisation would need to be abandoned to allow the source specific resource costs to be reflected in the prices faced by customers. Although properly constructed abstraction charges could provide an incentive for companies to make such changes, there are important inhibiting factors. In the first place the demand response of end users to the new tariff arrangements is uncertain (see Chapter 4). Second, companies are extremely reluctant to adopt measures which could affect short run revenue flows. If metering and new tariff structures do reduce demands, then clearly companies lose revenue but still have to cover in the short term the same fixed costs. Although the consequently reduced actual abstraction charges will help mitigate such losses, they are likely to be a minor consideration. In the long run, of course, reduced demand delays investment and so lowers costs but short run consideraions tend to dominate. Third, but closely related, volume based tariffs introduce greater revenue instability; this is particularly important where garden watering is a significant component of domestic demand. Fourth, any charging or tariff structure changes which alter the incidence of the service cost allocation between customers inevitably invoke hostile reactions. Finally, of course, the transation costs involved in introducing new charging methods and tariff structures are likely to be considerable, particularly so where meter installation is involved and where some method (peak recording meter or meter reading frequencies desinged to isolate summer consumption) of imposing summer use charges is introduced.

It is also worth mentioning that there is a chance that the metering of domestic consumers will have a counter-productive impact on the demand for water resources. This arises from an anomaly, identified by Herrington and Price (1987) in the way the system of price regulation operates. At present allowable price rises are related to average household water bills, therefore if average household consumption is increasing then the company's revenue yield per unit volume must fall. Companies deriving a considerable proportion of their revenue from unmeasured services and facing significant annual per household demand growth find that a proportion of the revenue derived from an allowable price rise will simply be absorbed by the costs associated with consumption growth. This effect is exacerbated if peak to average demand ratios are also increasing. In these circumstances, companies have an incentive to curb consumption, and particularly peak demand, growth by non-price means (hosepipe restrictions, reduced flows advertising and exhortation). However, on the introduction of metering the unit price will be subject to regulation, but profits could increase if the quantity of water sold increased. There is, therefore, a danger that companies will favour tariff structures which discourage conservation.

Overall, it seems unlikely that economically based abstraction charges will on their own produce major changes in company pricing behaviour. However, they could make an important contribution to the gathering campaign for the companies to adopt more use and cost based prices.

7.5.4 Leakage Control

For some considerable time now supply companies have been under pressure to reduce 'unaccounted for' water and the methodology for establishing 'optimal' leakage detection levels is well developed. Theoretically companies should regard leakage savings as an alternative to supply enhancement. Leakage detection costs per unit water saved should be compared to the full costs of increasing output from existing source works and in the longer term from supply enhancement schemes. Within already available abstraction authorisations, the costs of increasing supplies include capital and revenue expenditure on pumping from source, treating the additional supplies, pumping to service reservoirs and increasing the capacity of the trunk and distribution main system to cope with the increased demand. Where demand growth indicates that a further water source will be required the savings from deferred expenditure on supply enhancement must be taken into account.

At present abstraction charges are an irrelevant for the within authorisation case, and only a very minor element in the deferred expenditure on augmentation. Marginal opportunity cost based actual consumption charges would have an immediate and significant impact on the balance of advantage between leakage control and water output increases. Although by no means all companies follow the recommended procedure for determining the optimal leakage control effort, an increasing proportion are doing so and all are conscious of comparisons made between companies in reported loss levels. The expectation is, therefore, that in the short term the most important effect of an improved abstraction pricing policy will be to alter company leakage detection efforts. Only in the longer term will there be an impact on end user demands.

8 THE POTENTIAL ROLE OF ECONOMIC INSTRUMENTS

8.1. The National Abstraction Charge Scheme

It is recognised that the national scheme had to comply with two constraints imposed by the 1989 Water Act; first only to recover costs properly charged to the NRAs Water Resources Account and second, to avoid 'undue discrimination' in the allocation of such costs. The former does pose considerable difficulties for the introduction of incentive based pricing systems, but the latter should not create difficulties, since most legal interpretations of no 'undue discrimination' have concluded that differential charges related to costs imposed are not discriminatory. It is further accepted that any charging system needs to be cheap to administer and as straight forward as possible to aid abstractor understanding. Therefore, the NRA's rejection of a 'pure' cost based charging scheme, based on the individual costs imposed by each abstractor, is, in our view, correct; the administrative costs involved would inevitably outweigh any potential efficiency advantages, particularly given the revenue constraint. Some form of aggregation of abstractors into groups is, therefore, essential and the key issue is whether the aggregation system adopted is the best possible one to promote allocative efficiency.

There is no doubt that the flow factors (volume, season, source and loss) will normally be the critical ones determining the costs imposed by individual abstractions on the water resource system. But placing abstractions into categories based on these factors and then allocating regional aggregate costs to these groups, in reality takes the scheme a long way from the objective of relating charges to the impact of the abstraction on water resources. Indeed the imposition of national factors means that less attention is now paid to spatially differentiated impacts than occurred under most of the previous regional schemes. Major cross-subsidy flows between abstractors are inevitably occurring, but whether a legal challenge based on undue discrimination would be upheld is open to question (see OFWAT 'Paying for Water: Annex 1' 1991).

Having considered the question of cost attribution in some detail in Chapter 6, we remain unconvinced that a scheme based on nationally established principles need employ national weighting factors. The basic princple - that the impact of an abstraction on water resources (including the water environment) and the costs of source enhancement (ie. supported by augmentation) - could be employed to develop more spatially specific cost recovery charges without adding unduly to the NRA's administrative costs. Changes to accounting procedures - at least to enable differentiation between revenue and capital expenditure, ensure the regions were employing consistent expenditure classifications, and allow identification of the expenditure devoted to different functional activities - would in any case be desirable for the sake of good 'business' management.

8.2. The Weighting Factors

8.2.1. Volume

Although the theoretical principle behind the use of authorised rather than the actual abstracted volume as the charging base is valid, there are important reasons why the NRA should consider making greater use of actual consumptions at least as the basis for part of the total charge. As is well known past licence allocations have overcommitted abstraction capacity but many irrigators and all water companies are unwilling to relinquish licences in whole or in part for reasons already discussed. However, once the authorisation has been paid for, the NRA can only control use by exhortation and usage bans. In practice the latter are employed selectively to curb irrigation use but not water company abstraction, largely due to the statutory requirement that the NRA has to have regard for the duties of water undertakers. An alternative would be to employ rationing by price (see 2.2.5 and 2.3.4) in an attempt to cut the overabstraction allowed by the licence. Such a mechanism could be employed more widely, outside the catchments and ground water sources where overabstraction is a 'normal' rather than unusual occurrence, to cope with unexpectedly severe drought conditions; in this case a drought surcharge scheme could be employed. In our view, it is particularly important that water company abstraction charges have a significant actual use component since only then will there be any short run incentives to increase leakage detection and institute more efficient tariffs (7.5). Importantly, only with actual volume charges will the NRA be able to use pricing to influence water company decisions about which of their various raw water resources to utilize most heavily (clearly a more refined source weighting factor system will also be necessary).

There is no reason why demand rationing charges need be inconsistent with the cost recovery constraint, particularly if they are only employed to cope with specific capacity limit problems. Authorisation or application charges would need to be reduced to compensate. Undoubtedly, the greatest difficulties arising from the suggestion that actual abstraction schemes should be employed for charging purposes arise over the administrative, including informational, costs involved. It is sometimes argued that the need for metering imposes a significant constraint. In our view it does not; water companies already measure the raw water going into supply, irrigation charges are now based on actual and authorised volumes (but not with actual based charges at incentive levels) and most industrial abstractors are metered (in any case few of them would be caught up in overabstraction situations). A more serious difficulty lies in our lack of knowledge about the price elasticities of demand - the supply/demand balance point would have to be established iteratively. In a sense the NRA has little to lose by at least trying price rationing in selected overabstracted catchments. One alternative, to buy out licences, will be extremely expensive (there seems little likelihood that a legal change will allow uncompensated revocation) and the other alternative - permit trading - will not help in overabstracted situations unless abstractors are willing to see their entitlement reduced as the price for being allowed to sell their asset. In any case, the response to trading opportunities is as much an unknown quantity as is response to incentive prices.

8.2.2. Seasonality Factors

We remain concerned with the way that the season of abstraction is dealt with in the scheme. The weighting factors mean that all year round abstractors pay less for their summer consumption than do summer only users. This is economically unjustified; all summer users impose the same costs on the system irrespective of their annual use cycle. As was argued in chapter 2, all year round abstractors are being given false information about the costs imposed by both their summer and winter use. Only for ground water is there a case for an all year charge. In many cases the cost imposed by winter abstraction is zero. Given the cost recovery constraint, it would be possible to levy much higher summer abstraction prices if the minimal impact of much winter abstraction was fully acknowledged in the weighting factors. We regard this as particularly important in the case of irrigators, since our evidence suggests that the annualised costs of on-farm storage are typically small and any incentives given to farmers to embark on investment in storage could make a significant contribution to the water resource situation. The use of the same seasonal weighting factor for the whole country appears to have little justification. It is evident that the impact of summer abstractions on water resources and the environment must vary considerably over the country reflecting regional rainfall regimes. A spatially variable factor based on, for example, average summer rainfall data, would not seriously complicate the scheme and is built on a logic easily understood by abstractors.

8.2.3. Supply Source Factors

The weighting factors for source appear to us to be unduly crude, and do little to help the NRA fulfil its resource and environmental objectives. Too little attention is paid to the impact of abstraction on resource availability. An abstractor taking supplies from an overabstracted catchment will pay the same as one utilizing a source with excess capacity. Users of ground water will be charged the same irrespective of the state of the aquifer, even though in some areas major problems (and costs) are incurred due to rising water tables whereas elsewhere ground water levels are falling dangerously. Similarly, there is no incentive for an abstractor to take water from lower rather than higher up in a catchment; this is of particular relevance for the water companies who have some choice over intake points. Further, we remain unconvinced that tidal water abstractors should pay an availability charge at all; the costs of issuing the licence and monitoring their abstractions should be recouped by flat rate access fees. Even the low 0.1 factor can give rise to quite significant bills for large summer and all year round users.

Two points also need to be made about the classification of sources into supported' and 'unsupported' In the first place, it is not evident why the support factor should be applied to winter-only abstractors or indeed to the winter component of all year round abstraction. It is our understanding that support is necessary to meet usage during the peak demand-low flow period. Secondly, although it might be administratively convenient to regard all minor abstractors as 'unsupported' the aggregate contribution of clustered small abstractors can have significant augmentation costs. In the Vale of York augmentation scheme discussed in chapter 6, irrigators were significant beneficiaries of the scheme. The fact that their irrigation demand may be individually small does not mean that the value in use of the additional supply/reliability will not be high. Our farm survey evidence suggests that the gross margins generated by relatively small irrigation volumes can be considerable, in which case the farmers could afford to contribute to the augmentation costs.

It is acknowledged that a more source specific charging scheme does increase complexity, but given that detailed lists are already given of augmented sources it would be excessively difficult to add a 'vulnerable' source category. What is important is that the charging scheme gives the best signals possible to abstractors about the impact of their use on resources.

8.2.4. Loss/Return Flow Factors

In many respects this aspect of the scheme causes us the greatest difficulty. While it is admittedly very simple to use purpose as a surrogate for loss levels, when combined with charging for authorised consumption, it removes any possibility that the charge can provide any incentive to economy. Industry, for example, gets no charge remission for introducing recycling unless they also go through the procedure of releasing part of their licence; likewise the water companies see no recompense for major leakage control efforts. The new cost-related disposal charges incorporate volume bands and trade effluent charges are already volume based; data, therefore, exists to refine the loss factor, and this would clearly be necessary if the Goverment's consultation paper 'Using Water Wisely' produces moves towards incentive pricing. In the meantime, the possibility of having an additional loading for the use of once through water systems, might provide some impetus towards recycling for those industries already contemplating investments for pollution control reasons.

Perhaps even more importantly, the scheme takes no account of the *value* of the return flows. Although by and large water returned during winter will be irrelevant, the value of summer return flows must vary considerably depending on location of discharge. The placing of water supply and industrial purposes in one loss category irrespective of return point, gives absolutely no incentive for returns to be made where they can contribute most to resources. This is a particularly crucial defect for the water company sector and appears to be detrimental to the NRA's policy of improving summer river flow conditions. Additionally, it is felt that the range of factor weightings is not great enough to fully reflect the differential resource costs involved. In particular, the weighting for the high loss category is now much lower than those employed in most of the old regional charging schemes. As discussed earlier the use of national weightings, while having simplicity advantages, takes no account of the wide regional differences in the value of return flows.

8.2.5. Adjustments to the Scheme Under Current Legislation

The revenue constraint is a major problem for the introduction of incentive pricing, particularly as the short-term elasticity of demand for most abstractive purposes appears to be relatively slight at low unit price levels. It is our view, however, that even within this constraint it would be possible by careful targetting of the charges to those areas and periods where the costs/ damage from abstraction are highest, to get unit price levels up high enough to start influencing abstractor behaviour. Our evidence suggests that relatively minor adjustments to the way the weighting factors are applied would produce unit prices for summer irrigation use which are at or above the average annualised cost of storage plus a winter only licence. This should provide a considerable incentive to develop on farm storage, particularly as reliability would also be improved. However, it may be necessary to institute some loan scheme to overcome the capital availability constraints. Table 8.1 illustrates the way alternative weighting systems might operate in the agricultural case (for simplicity the actual/authorisation charge split is ignored).

Other abstraction sectors are likely to be less responsive, in the short term to such adjustments to weightings. However, this does not mean that the messages

SURFACE WATER	PRICE PER MEGALITRE
WINTER STORAGE SCENARIO FACTORS:	
WINTER SEASON = 0	
SUPPORT = 3	
HIGH LOSS = 5	
STANDARD UNIT CHARGE	
HIGH = 10 *	
LOW = 5.5 *	
(a) 0 x 5 x 3 = 0	ZERO
(b) 0 x 3 + 5 = 5	HIGH = £27.50
	LOW = £50.00
SUMMER ABSTRACTION SCENARIO FACTORS:	
SUMMER SEASON = 5	
SUPPORT = 3	
STANDARD UNIT CHARGE	
HIGH = 10*	
LOW = 5.5*	
(a) 5 x 3 x 5 = 75	HIGH = £750
	LOW = £412.50
DIFFERENCE SUMMER ABSTRACTION TO WINTER STORAGE	
	HIGH = £665.45
	LOW = £350.45

Table 8.1 Alternative Weighting Factors.

* High and Low Standard Unit Charges are Used Inorder to Take Account of High Cost Areas Such as Anglia.

contained in the pricing structure are, therefore, of no importance; they are relevant when investment decisions are made. Large, multi-plant companies in particular appear to be becoming sensitive to the total water/wastewater costs within their plants and when economic recovery occurs many firms will be updating process technology. When making decisions about investments which have an impact on water use, firms are unlikely to consider water saving as an objective in its own right if the abstraction tariff structure tells them that whatever they do the charge will remain the same. It is worth stressing that for our very small case study group the cost of recycling was actually rather small, suggesting that the value of once through water is low.

Under a revenue constraint, it becomes particularly crucial for the NRA to focus the volume related charge on the damaging abstractions and put to zero the factors where the impact of the abstraction is negligible. The most obvious way of doing this is to regard *all* winter use (except for groundwater) as having minimal resource relevance and to load the charges onto summer use. Further, it is worth noting that if the charges do generate a significant response from abstractors this will act to reduce the revenue take, thus lessening the excess earnings problem.

It would seem to us that even with the revenue constraint it is worthwhile for the NRA to improve its knowledge of the costs currently incurred for the benefit of particular abstractor groups. As was seen in chapter 6, the practice of spreading augmentation costs over all abstractors within a region (albeit with an additional support factor) is giving users a false picture of the real cost of their enhanced supply (see 6.4.4 for the Barmby barrage case). Although the type of hierarchical cost allocation system recommended in that chapter, will obviously increase administrative complexity, it is a prerequisite for the development of charges which have any relationship to the full costs imposed by particular abstractions.

8.3 Towards a Full Incentive Charging Scheme

Even with the removal of legal constraints, a pure marginal opportunity cost based charging system is unlikely to be a feasible proposition. In the theoretically optimal form the costs imposed by abstractors on other water users, including the environment, would need to be calculated; such costs vary enormously over space and time and would be virtually unique for each abstraction. Moreover, it is doubtful whether the 'art' of damage/loss assessment for in-situ users will become refined enough within the foreseeable future to become an acceptable charging base.

It would, however, be possible to base an incentive charging system on long-run supply capacity or flow enhancement costs. If 'politically' determined stream quality standards are set *and* acceptable minimum flow levels established to protect valued amenity and wildlife resources, then broad estimates can be made of the costs involved in meeting these standards by increasing storage capacity to provide the necessary 'amenity' and dilution water. This approach has already been discussed in 5.3.3, in the context of attempting to develop surrogate value in use measures for water used to dilute and assimilate wastes. In essence it employs damage avoidance costs rather than damage costs themselves as the charging base. The balance between extractive and 'in-situ' uses would *not* be established on economic efficiency criteria, but economic principles and tools could be employed to reach the chosen balance. If this method of long-run opportunity cost estimation was adopted, it would be used as the basis for both abstraction and direct discharge pricing. Equivalent increases in withdrawals or discharges would both involve the same capacity enhancement costs to enable the required river quality standards to be met; there is a logic, therefore, in employing such enhancement costs as the charge base.

Once the long-run marginal enhancement costs had been established for specific river or ground water systems, it is then necessary to decide how to apply such costs to particular units of abstraction. It would no longer be necessary to levy differential charges depending on whether the abstraction source is supported or unsupported, since the marginal unit charges would now be based on potential future 'support' costs for all sources. Loss/return factors, season and the ground, surface, tidal water distinction would still be relevant. Ideally, the unit charge should be levied on 'consumed' volumes only; in other words doing away with the separate 'loss' factor. An incentive would then be given for industry to avoid once through systems and for water companies to reduce network losses. This will be much easier to do if direct discharge and abstraction charges are incorporated into a combined system (with appropriate adjustments made for disposals via the sewerage system). However, it would be desirable to add some form of locational weighting to encourage the construction of off-take points in the lower reaches of a catchment and the return of discharges as high up in the catchment as possible. As argued earlier, for most surface water sources the long-run enhancement costs should normally apply only to consumed summer units, but for ground water,season need not be a relevant issue.

Ground water sources do add a complexity to the enhancement cost system. First, in a sense all units abstracted are consumed in that they are not returned to source, but an allowance might be given for returns via the sewerage system which contributed to the summer resource position. Second, we understand that it is not physically feasible to enhance some ground water systems. In this case, once minimum acceptable aquifer levels have been established, the problem is how to allocate a fixed supply quantity. As suggested earlier permit auctions and their trading is likely to be the simplest way to cope with such cases using economic mechanisms. The alternative of employing a demand choking or rationing price suffers from lack of information about the demand elasticities of abstractors. Third, there are some cases where excess water not potential scarcity is the key issue (i.e. in rising water table areas). Prices set at enhancement costs (if calculable) would simply exacerbate the problem. For such cases, the solution is not to levy any volume related availability charges, but to set flat rate access fees to cover the NRA's basic costs in administering licences and monitoring aquifer levels.

There is no doubt that an incentive based charging scheme would be more costly to administer, although this could be significantly reduced if a combined water/waste water scheme was adopted. The informational problems involved are not major if supply enhancement costs can be employed as the charging base and if the NRA improve their cost allocation and accounting procedures. It is not evident that an incentive system will be any more difficult for abstractors to understand than the current arrangements, although the fact that prices will vary between catchments might raise 'political' objections.

Key difficulties with a marginal enhancement cost system are, however, the issue of excess profits (see 2.5.2), and the related problem of 'lumpy' augmentation expenditure. It would be conceptually possible to consider an increasing block tariff structure so that only the last units of water abstracted by each user are priced at the full marginal enhancement cost. Given that abstraction volumes vary enormously this will be difficult to implement, although it is possible that when only 'consumed' units are considered the differentials will be reduced. Another alternative would be to redistribute the excess profits in grants/subsidised loans to manufacturers and irrigators to encourage the installation of recycling and storage facilities or to water companies to realign their supply systems away from the most vulnerable and high enhancement cost sources. Many economists have been reluctant to endorse such subsidies on efficiency grounds, but redistributive charges are commonly employed in Europe to speed up and help fund pollution abatement. If the Treasury would allow this form of hypothecation to apply in the abstraction case, recycled 'excess' profits could significantly ease the implementation of the higher incentive charges since their distributive impacts would be reduced. The excess profits could also, of course, be employed to compensate licence of right holders for revocations, where even full cost pricing failed to produce the hoped for demand fall

A further way to make incentive charges more acceptable would be to implement them over a set period, rather than in one year. The pace of implementation could also be varied to cope with the varying immediacy of enhancement needs. In over abstracted catchments the full cost prices could be levied in Year 1, but elsewhere calculations could be made of the time at which enhancement was needed to meet demand growth, and charges set on an increasing scale to reach the full costs by that date. Such calculations would be relatively easy for water company demands, but are made more difficult for other abstractors because we lack data on how demands would have increased naturally if licence restrictions did not exist.

It has to be noted that even full enhancement cost pricing is likely to take some time to effect a significant change in water using behaviour by all abstractor groups. Short run demand elasticities appear to be slight. However, in the longer term the impact of prices which reflect the true costs of abstraction could be considerable. As has been shown, storage is a viable alternative to abstraction at needed time of use for many irrigators. In addition for those abstractors where the gross margin analysis revealed that irrigation is not economically viable when the capital costs were taken into account, the expectation must be that some will drop out of irrigated agriculture when equipment replacement is necessary. However, some will retain the practice for insurance (risk reduction) reasons. Likewise in the industrial case, since the value in use of 'once through' water appears to be low, over time as investment in new plant occurs, properly constructed water and waste water charges should produce a marked shift towards recycling.

8.4. Permit Trading

Tradeable permit schemes would in our view be most appropriately applied where supply enhancement was seen to be politically or environmentally undesirable or was physically impossible. In areas where overabstraction is already a problem, trading would *either* have to be preceded by licence revokation and an auction of available capacity held *or* each licence would have to be reduced by the appropriate percentage to get the tradeable quantity down to capacity.

As discussed in chapter 2.7, while permit markets have clear theoretical efficiency problems, there are practical problems involved in their implementation. Trading will only occur if there is actual or perceived scarcity of potential water sources (chapter 7.4). Our, admittedly limited, evidence, suggests that manufacturers would not at present be responsive to trading opportunities and that the likelihood of the water companies offering any of their established licences for sale is remote. Only irrigators seemed alive to the potential for trading, with expressions being made of willingness to sell and buy licences. Since the marginal value in use of water appears to vary markedly between irrigators, trades could significantly increase the efficiency of water use within restricted areas. The high costs of transporting supplies between catchments would probably limit the scope for longer distance trades.

We would recommend that before embarking on any widespread permit trading system, the NRA considers the possibility of a more limited experimental scheme, concentrating on agricultural abstraction and restricting trades to within sectors. Such a restriction will, of course, limit the potential efficiency advantages, but it would make for a simpler system. If industry and water companies were to be included the whole issue of return flows and their location would have to be addressed, potential monopoly buyer problems would arise, and distributional difficulties associated with potential agricultural sector run down could occur.

The more limited experimental trading scheme would allow the NRA to test the significance of two potentially important problems created by trading. First, our data indicates that the highest water values are associated with very intensive farming practices, where high inputs of fertilisers and pesticides are employed. Trading would probably move available supplies to such intensive farms. Therefore, the NRA would need to consider carefully whether the benefits from an improved water allocation exceeded the potential damage created by increased pollution. Second, the resource implications of 'sleeper' licences needs to be explored. Although some un,or partially used licences are held for insurance purposes, it is possible, given the reaction of our interviewees, that trading would release some sleeper licences, so exacerbating resource problems. In all probability, trading would be most active if irrigators were allowed to trade water on short-term contract (say up to five years) without releasing the licence itself. In other words the licence holder would retain the risk avoidance and land value enhancement advantages of the licence, while making a gain on the water sale. However, this would tend to exacerbate the 'sleeper' licence problem.

8.5 Lost Opportunity Costs, Reasonable Needs and Resource Augmentation Needs

Conceptually, we know that there must be lost opportunity costs from the first come, first served system. What these are in practice remains unknown. There are three possible ways of gathering information which could shed light on the matter. First, existing licence holders could be asked whether they had been denied a licence extension and what impact this has had on the company or farm - this was done for enterprises within our sample surveys. Second, data could be gathered on concerns who had been denied a licence; as explained earlier this proved impossible to pursue since the NRA regions do not keep records of 'informal' rejections. Third, if good value in use data were available it would be possible to model for particular catchments the abstraction allocation which would maximize the total value in use from a set supply quantity. However, this would only be possible if it were assumed that only existing abstractors were party to the allocation. Moreover, at present the value in use data is too restricted to make the exercise have much practical relevance. Our comments here are, therefore, based only on the surveyed abstractors.

For the manufacturing sector it is difficult to argue that the first come, first served system has imposed any opportunity costs. None of the sampled firms had been denied a licence extension or had restrictions imposed on their pattern of usage. It has to be stressed that this result may simply be a reflection of the areas studied and of the fact that a large proportion of the sample took supplies via the BWB canals. As expected, more irrigators reported constraints on their ability to obtain licences for usage at time of irrigation need. In the vast majority of cases, however, winter only licences were available. Only in two cases had licence refusal imposed significant costs on farmers. One farmer on sandy soil reported the inability to extend his licensed quantity to allow him to adopt a normal rotation of high to average value crops. More of the land had to be put to cereals, which on this soil type markedly reduces gross margins. For a farmer in this position the possibility of obtaining extra supplies via permit trading is an attractive proposition. The second case already referred to in chapter 3 provides an example where licence refusal has led to the farm becoming an economically unviable unit. Irrigation was only viable if the acreage could be extended to cover fixed costs plus the additional labour needed for horticultural output. But without irrigation the unit wasn't profitable at all. The future survival of the farm is dependent on the obtaining of planning permission for a housing infill site, which would allow the purchase of land adjacent to the currently irrigated acreage to enable the construction of storage. Clearly no generalisable opportunity cost figures can be produced from only two cases.

The concept of reasonable needs is inseparable in economic terms from the notion of value in use and resource augmentation needs. A reasonable need can be established by comparing the current value in use with the costs of providing additional supplies. Our evidence would suggest that for many existing industrial abstractors there is minimal reasonable need for additional supplies, since the efficiency with which currently available water is used is low. As has already been discussed the value of once through water as measured by the cost of recycling is not high and becomes very low when the energy cost and pollution control saving from recycling are introduced. Inevitably, when recycling has been introduced the costs of installing still more water efficient technologies escalates and the value in use (and thus reasonable need) of supplies increases markedly. For the water company sector in the short term the simplest way to approach reasonable need for additional supplies is to compare the costs of improved leakage control with the costs of capacity development (see 7.5.4). In the longer term any definition of reasonable needs has to address the question of the charging methods and tariff structures adopted by the companies when selling supplies to end users. The reason why this is viewed as a longer term issue lies in the need to instal meters before tariff structures have any relevance to domestic consumption. In economic terms it would not be reasonable for the NRA to demand metering as a precondition for allowing increased raw water supply capacity. As Ofwat have argued what is crucial is that the cost of metering is compared with the annualised full cost of supply enhancement, which not only includes the additional raw water capacity but also the extra treatment (recurrent and capital) costs, the additional distribution expenses and the reduced costs of leakage control. The value of delayed expenditure should also take account of the initial effect of metering on demand (plus leakage) and the subsequent impact of increased per unit water prices on the demand trend line.

In the agricultural sector a distinction has to be made between reasonable needs for abstraction at time of use and for stored winter water. For many farmers on farm storage costs are low and thus there is little need for summer abstraction. On the other hand if on farm storage costs exceed the NRA's cost of augmenting summer flows, then it would be reasonable to allow additional summer abstraction providing, of course, that the irrigator is prepared to pay the enhancement costs. Certainly, it would be preferable to expand raw water capacity explicitly for the high value crop sector rather than to force irrigators to take expensively treated supplies from water companies. As indicated in chapter 3, there are already cases where the gross margin yield from irrigation over dry farming exceeds the costs of mains water plus annualised equipment costs. For the group of irrigators producing high value horticultural and field scale vegetable crops, the survey results indicate unexpectedly large gross margins over dry farming; once low cost on farm storage opportunities have been exhausted then flow augmentation would be reasonable. Alternatively, it is possible that their additional needs could be met within existing capacity by permit trades and water transfers.

The current difficulties over the definition of reasonable needs and augmentation needs would largely be solved if the NRA adopted the long run enhancement cost based charging system discussed earlier.

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Appendix I:- The Agricultural Questionaire.

Note, the Industrial and fish farms questionaires cover the same issues as the agricultural, with ammendments, and will not be reproduced here.

There were additional questions administered to the Industrial sample to ascertain the ownership and organizational characteristics of the firm.

THE VALUE OF WATER IN AGRICULTURE: IRRIGATION AND OTHER FARM APPLICATIONS

FARM SURVEY SUMMER 1991

NRA Abstraction licence code

Farm Code

Interviewer Code

Date

1. SOURCES OF NON-DOMESTIC FARM WATER

(A) Mains Yes/No
metered Yes/No

Under 'normal' weather conditions what approximate quantity of mains water do you use?

0-48,000 Gallons
48-100,000 Gallons
100-250,000 Gallons
250-500,000 Gallons
500,000-100,00000 Gallons
Over a Million (specify)

What do you use the metered water for?

(B) Abstraction licence water

Details of abstraction licence(s) held:

Licence No.	Period	Quantity	Source	Use

Please complete

(please tick months abstracted then for quantity put in actual amount)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Actual quantity abstracted												
Actual period of abstraction												

Were the terms of this licence those that you wanted?

(i) Quantity of water applied for? YES/NO

(ii)Was the quantity you wanted reduced through pre application discussion with the NRA?

(ii) Period of abstraction applied for? YES/NO

(iii) To extend the area covered? YES/NO

Have you ever applied to have your current licence amended?

(i) To increase the abstraction quantity YES/NO
By how much?
Reasons

(ii) To extend the period of abstraction YES/NO

(iii) To extend the area covered YES/NO

(iv) To decrease the abstraction quantity YES/NO

(C) Additional water sources

Do you obtain water from other sources? YES/NO

If yes, what is the source of this water, and the quantity taken?

2. ON FARM WATER STORAGE

(i) Do you have any form of on farm water storage? YES/NO

If YES, complete the table below

Type	Capacity	Date installed	Cost	Grant	Comments

IF the water storage facilities are in fact catch pits, which have been dug by gravel companies :
Would you still go ahead and install storage facilities if you had to bear the full cost yourself? (ie there was no "deal" with the gravel company)

3. WATER RECYCLING

Do you recycle water?

If YES, what system do you operate?

Why did you introduce such a system? Were you motivated by

(i) a need to reduce abstraction charges?

(ii) a need to increase the reliability of water supply?

Type	Capacity	Date installed	Cost	Grant	Comments

4. NATURE OF FARM BUSINESS

What is the dominant soil type on the farm?

What is the total utilised area?

What is the acerage owned?

What is the acerage rented?

(please enter details in cells)

	Arable	Permanent Pasture	Horticulture/ Fruit	Glass	Other
Area Owned					
Area rented (formal)					
Area rented (informal)					
Area rented out (formal)					
Area rented out (informal)					
Total irrigated Area					

5. CROPPING PATTERNS (1989/90 season)

What arable rotation do you follow?

What was your cropping pattern during the 1989/90 season?

	Total Area	Area Irrigated	Yield Total area	Yield of irrigated area
Winter Wheat				
SpringWheat				
Winter Barley				
Spring Barley				
Grain Maize				
Rye				
Oats				
Other Cereals				
Vining Peas				
Dried Peas				
Ordinary Peas				
Spring Beans				
Winter Beans				
Broad Beans				
Vining Beans				
Beans Other				
Onions				
Carrots				
Suga Beet				
Early Potatoes				
Main crop Potatoes				
Oil seed rape				
Linseed oil				
Permanent Pasture				
Grass (Hay/silage)				
Strawberries				
Raspberries				
Gooseberries				
Other Soft Fruit				
Flowers				

6. LIVESTOCK ENTERPRISE (1989/90 season)

Livestock	Numbers
Dairy	
Beef Cattle	
Sheep	
Pigs	
Poultry	
Goats	
Horses	

7 RELIABILITY OF LICENSED WATER ABSTRACTION

(i) Under 'normal' weather conditions is the abstraction water sufficient to meet demand?

If NO, do you use mains water to supplement abstraction water for such purposes as irrigation?

If YES when?

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Number of weeks												
Quantity												

If NO why not? Cost?
Location of Supply?

(ii) Under 'dry' weather conditions is the abstraction water sufficient to meet demand?

If NO, do you use mains water to supplement abstraction water for such purposes as irrigation?

If YES when?

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Number of weeks												
Quantity												

If NO, why not?

If NO, should mains water cost 10% less would irrigation then become viable?
20%
30%
40%
50%

8 ISSUES SURROUNDING ON FARM WATER STORAGE

(i) Under 'normal' weather conditions, would the storage capacity be sufficient to meet the needs of the farm?

If NO, for how long would the stored water guarantee supply?

(ii) Under 'dry' weather conditions how long would the stored water last?

(iii) What do you do when you realise that the stored water is inadequate to meet your needs?

- (i) Use mains water
- (ii) Obtain water from other sources..specify
- (iii) Accept lower yields/poorer crop
- (iv) Initiate night time irrigation
- (v) Conserve water through more efficient irrigation practise eg trickle irrigation
- (vi) Other (please specify)

(iv) What do you do if/when the stored water is exhausted?

- (i) Use mains water
- (ii) Obtain water from other sources..specify
- (iii) Accept lower yields/poorer crop
- (vi) Other (please specify)

9. IMPACT OF IRRIGATION ON CROPPING PATTERNS.

What would the cropping pattern and yields revert to if the abstraction licence were removed?

If the abstraction licence guaranteed the supply of the licenced quantity of water, what would the cropping pattern and yield revert to?

	Irrigation in absence of abstracted water	Irrigation in absence of abstracted water	Irrigation with guaranteed abstracted water supply	Irrigation with guaranteed abstracted water supply	Change in quality/ quantity
	Hectares	Yield	Hectares	Yield	Comments
Winter wheat					
Spring wheat					
Winter barley					
Spring Barley					
Grain Maize					
Rye					
Oats					
Other cereal					
Spring Beans					
Winter Beans					
Broad Beans					
Vining Beans					
Other Beans					
Vining Peas					
Peas					
Sugar Beet					
Early Potatoes					
Main crop potato					
Oil seed rape					
Linseed oil					
Onions					
Carrots					
Other Veg					
Strawberries					
Raspberries					
Gooseberries					
Other soft fruit					
Flowers etc					
Grass/ Hay/Silage					
Permanent pasture					
Other					

(iii) What would the cropping pattern revert to with a supplemented water supply(ie more water

Would you change the seed variety ?

What would be the impact on the quality and yield of the crop?

10. INVESTMENT IN CURRENT WATER MANAGEMENT EQUIPMENT

Investment in irrigation equipment

Type and quantity	Expansion or replacement	Capacity	Date Purchased	Cost	Grant

Can you give a breakdown (in percentage terms) of the operating costs of the irrigation system?

Operating costs:

Abstraction Licence
Maintenance
Labour
Fuel
Other

11. CAPITALISATION OF WATER ABSTRACTION RIGHTS

CURRENT LICENCE SCHEME

Have you any experience of the impact of abstraction rights on land values and/or rents? YES/NO

If you didn't have the abstraction licence how would this affect the value of the land?

How much less would you expect to pay?

Could you indicate the impact of these rights

	Rents	Land Values
40-50%		
60-70%		
80-90%		
100%		

Would you be willing to pay a premium for land with abstraction rights? YES/NO

If YES please indicate how much in percentage terms.

	Rents	Land Values
40-50%		
60-70%		
80-90%		
100%		

TRADEABLE LICENCE SCHEME

Have you ever considered buying or selling some of your licensed quantity of abstraction water on a short/long term basis to another user (with NRA consent)?

If YES, what would you consider to be an appropriate price? (price per 1,000 litres)

If a new type of licence were introduced that were directly tradeable between the licence holder and another water user, would you consider this a favourable development?

LICENCE WITH INCREASED RELIABILITY

(Specifically Summer licences OR all year licences in the summer monthes)

What proporion of years is current water availability adequate to satisfy your farm needs?

Consider an absraction licence were introduced which guaranteed to meet your on farm water needs in four years out of five. What premium above the current licence fees would you be prepared to pay?

	Reliability			
Premium	4 out of 5 yrs	9 out of 10 yrs	19 out of 20 yr	
0-4%				

5-9%				
10-14%				
15-19%				

12 FUTURE PROSPECTS

i) Is your farm business currently restricted by lack of water Yes/No

ii) Do you wish to raise the level of abstraction (assuming maintenance of current farm size and structure)

	Yes/No	Quantity galls	Period	Area covered by irrigation
before end '91				
1991/2				
1992/3				

(iii) Do you intend to instal water storage facilities on your farm?

	Yes/No	Type	Capacity	Cost/Grant
before end '91				
1991/2				
1992/3				

(iv) New investment in water management equipment over the next two years

Type of Equipment	Replacement/ Additional Capacity	Increase in Capacity	Cost	Reason

13. OTHER COMMENTS

Appendix II:-Notes.

‡ Price elasticity simply measures the relationship between price and quantity taken. It is percentage change in quantity divided by percentage change in price. If elasticity is greater than 1, demand is said to be elastic, below 1 is inelastic.

‡‡ These calculations assumed a 14% rate of interest, it is unknown how sesitive the results are to interest rate variations.

‡‡‡ 1 acre inch = 1 tenth of a megalitre.

1 acre foot = 1.2 megalitres.