Project Number 0248

Economics of Water Resources Management

First Progress Report

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NRA

National Rivers Authority

CONTENTS

EXECUTIVE SUMMARY

This is the first 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. The project as a whole includes analysis of both the demand side of water use, including the value in use of water for different consumers, and the supply side, especially the disaggregation of the costs of the NRA itself. There is also a particular focus on the problems of over-abstracted catchments, the costs imposed by supply unreliability and the demand for improved supply security.

Attention in this preliminary report is focused on two main areas: The theoretical princples applicable to water resources management and a review of the existing charges schemes inherited by the NRA. The report has an introduction and five main chapters. The first two substantive chapters (2 and 3) take efficiency as the goal and review the basic economic principles, outline the resulting ideal tariff structures, and highlight the problems in their implementation. Also considered is the use of less traditional market based allocation methods such as tradeable permits. In Chapter 4 a multi-objective approach is taken so that efficiency is no longer the only criterion for assessing the potential of market mechanisms. Chapter 5 reviews experience overseas. Chapter 6 is a critical appraisal of the NRA's existing schemes, including some suggestions as to how they might be brought into line with the principles discussed earlier.

Key Words

Water resource economics, abstraction charges, tariff design, marketable rights

1. INTRODUCTION - OBJECTIVES AND REPORT STRUCTURE

1.1. Research Objectives

The basic aims of the first stage of the water resources economics study were to:-

a) Conduct a literature search for theoretical and empirical material on tariff design, marginal cost estimation, demand estimation and overseas experience of abstraction pricing, regulation and allocation.

b) Examine the range of water resource management objectives and establish a methodology for assessing the relative performance of alternative pricing and other market based allocative systems against the objectives.

c) Set out the basic theoretical approaches to water resources allocation and identify the methodological and practical problems involved in implementing strategies based on such theoretical principles.

d) Evaluate (i) the existing charging schemes operated by the NRA and (ii) the future national approach to abstraction charges.

e) Establish and evaluate the market based allocative systems in operation overseas.

f) Set up the research programme for the empirical aspects of the project, including the choice of locations for the overabstracted catchment study and for the NRA cost disaggregation work.

1.2 Progress

Progress has been made against all these aims with the exception of (d (ii)) and (f). The new national charging scheme has as yet to be finalised and we would aim to give NRA our comments on the scheme before the end of the public consultation process. With regard to objective (f), initial discussions have been held with David Evans in which we outlined the ideal requirements for the catchment and costing study areas. Two potential overabstracted catchments have been identified in the Anglian region and information on these has recently been supplied to the Hull team. Details on appropriate catchments with significant industrial and urban abstractors are still awaited. Clearly detailed design of the field research programme cannot take place until the catchments have been identified, the quality of available data assessed and the characteristics of the chosen catchments evaluated.

1.3 Potential Programme Modifications

The river basin system to be used in the cost profile study has likewise not been finally chosen and in view of discussions with Peter Herbertson, who has been responsible for the NRA's internal review of abstraction charges, it seems likely that we may need to modify our proposals for this part of this project. Some cost disaggregation and cost modelling work has apparently already been undertaken in-house by Bob Taylor of the NRA Yorkshire region. To avoid duplication of effort we need to ensure that our work complements the studies already undertaken. It would appear that massive differences exist between NRA regions in the quality of available cost data, the conventional practices adopted in allocating costs to different heads, and in the levels of expenditure by purpose. Such differences will not significantly affect our original study objective of establishing a methodology for developing cost related tariffs. However, they do suggest that work on a single river basin could produce a highly misleading picture of NRA cost profiles. Further investigations will be necessary to ensure that our study is conducted in a way which enables us to develop a range of feasible tariff structures based on the different cost/purpose profiles typically faced by the Authority.

Further modifications to the research programme may also be desirable to take advantage of the abstraction data base created by the Herbertson review team. This has been developed to model the impact of alternative abstraction charge levels and weighting factors on different groups of abstractors. At present the modelling exercise is essentially static, in the sense that it ignores the response of abstractor groups to the change in water prices. Whilst this *may* not be a significant problem at current price levels, in the longer term NRA forecasts of abstraction demand could be highly distorted unless the differential price elasticities for water by user group are taken into account. It would seem appropriate for the Hull project team to become familiar with the modelling activity in order to assess the practicality of extending its scope to encompass future potential pricing scenarios *and* differential price elasticities. The possibility of employing the data base to test the applicability and likely impact on abstractors of alternative (non unit price) market based allocation techniques, such as tradeable permits, could also profitably be evaluated.

1.4 Structure of First Report

The report comprises five main chapters. First, the conventional theoretical approach to water pricing is briefly outlined (Chapter 2). From this the pricing rules and principles underlying efficient pricing structures are spelt out and the problems involved in their implementation are highlighted (Chapter 3). This section of the report concludes with a brief review of the potential role of non price market allocation tools, such as tradeable permits. Economic efficiency is not, of course, the sole objective of any water resources management agency. In Chapter 4 a multi-objective approach is taken. Alternative management goals are considered and efficiency becomes only one of a set of NRA policy goals. The potential conflicts between these goals are considered and the constraints non-efficiency objectives place on tariff design and market trading are evaluated.

In Chapter 5 attention is focussed on overseas experience with abstraction charges and with marketable permits and auctions. Over the last five years it is evident that the latter tools have become much more widely accepted as appropriate allocative devices, particularly in countries where established private abstraction rights are a major barrier to the efficient allocation of water between users. They also obviate the need for the resource management agency to obtain the detailed information necessary to establish efficient unit price levels and pricing structures. Whereas the recent theoretical and empirical literature is replete with material on permit trading and auctions, remarkably little recent attention has been paid to refining and implementing unit abstraction charging systems.

The final chapter of the report evaluates the existing NRA charging schemes against the criteria established in the previous sections.

2 THEORETICAL APPROACHES TO ABSTRACTION CHARGING

2.1 The Efficiency Objective

Efficiency involves three distinct, but related, elements :- technological, product and allocative. *Technological efficiency* means that a given output of a particular good or service is produced using least-cost methods of production. *Product efficiency* involves the production of the range, types and qualities of outputs which reflect consumer preferences. Abstraction water is, of course, not just one product but several with vastly different qualities, reliabilities and locations. Under competitive conditions it is axiomatic that a firm will only stay in business if its output matches customer requirements, but this clearly is not the case for a public sector 'monopoly' business such as the NRA.

Allocative efficiency is concerned with the entire distribution of factors of production and goods and services within an economy. Various definitions of this form of efficiency have been devised, but the most widely employed is the *Pareto* criterion. Resource allocations are efficient if it is impossible to reallocate some resource units between users to make some consumers better off without simultaneously making others worse off. In reality, however, this pure efficiency criterion can rarely be made operational; most resource allocation decisions will cause some people to gain at the expense of others. For this reason modifications to the Paretian rule have been made which involve the so-called compensation test. A resource allocation can still be efficient if the gains made by some people are great enough to allow them to compensate the losers (Figure 2.1). Allocative efficiency, under the compensation rule, basically means the maximization of *net* benefits from the allocation of factors of production, goods and services. This clearly has implications for distributive equity, since an allocation *could* be efficient if 90% of a particular product went

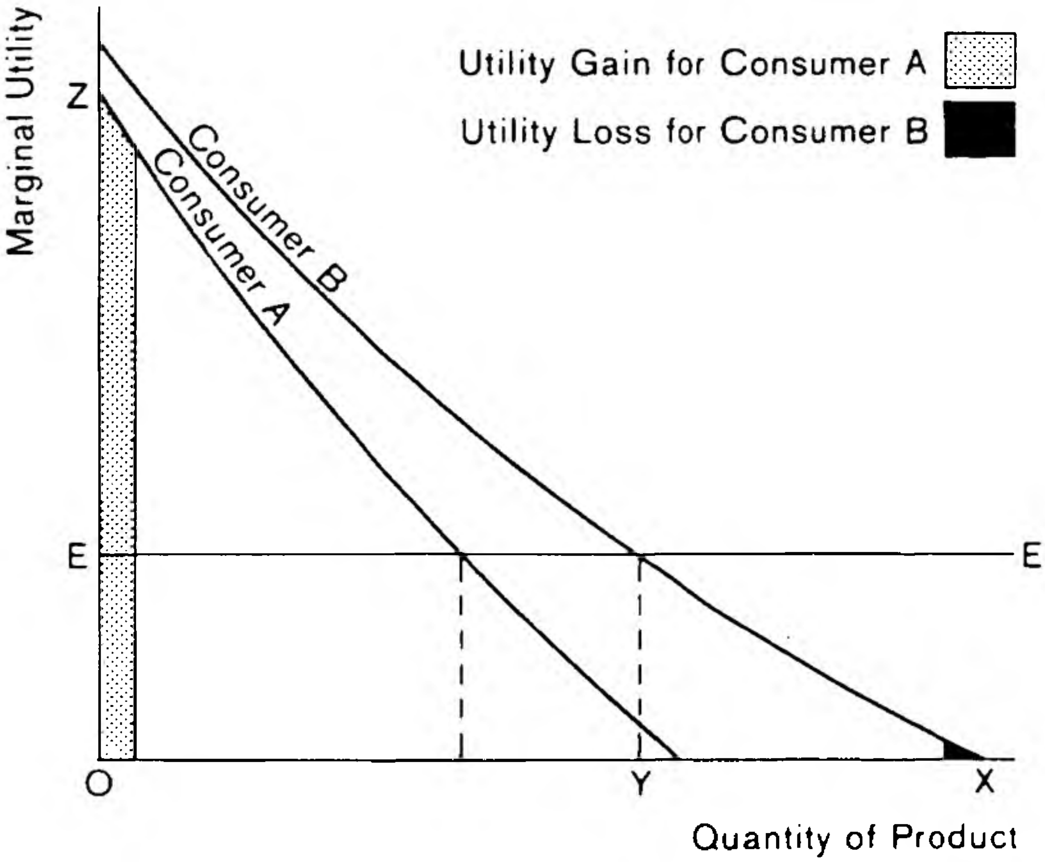

Figure 2.1. Marginal utility curves and the compensation rule.

The figure shows the demand (marginal utility) curves of two water consumers. Let us assume that we start from a situation in which consumer B has 0X units of water and consumer A has nothing. The value B places on an extra unit of supply is zero, but the value to A would be 0Z. Total value in use would clearly rise if supply units were transferred from B to A. No further transfers could occur once XY units have been taken from B. The value of water is now equal for both consumers and E is the price that both should pay.

to just 5% of the potential users.

To economists both product and allocative efficiency can be ensured by the adoption of appropriate pricing policies, assuming, of course, that consumers respond rationally to price signals. As we discuss later this assumption is by no means always valid; consumer behaviour is in reality a complex matter. Technical efficiency has nothing to do with pricing strategies, except that if technical efficiency does not exist then even a perfect charging system will still fail to produce allocative efficiency.

2.2 Theory : The Basic Case

2.2.1 Marginal Cost Pricing

The traditional measure of welfare employed in evaluating public utilities is the sum of producers' and consumers' surpluses. The former is just producers' profits; the latter is a measure of consumers' total willingness to pay for the good concerned over and above what they actually do pay (see Figure 2.1) This can be written more formally as

$$W = TR + S - TC \qquad (1)$$

where W is net social benefit (or welfare), TR is total revenue, S is consumers' surplus and TC is total costs. Then it can be shown that maximisation of W requires that the price of the good should be set equal to its marginal cost. This solution is shown in Figure 2.2. Alternatively we can argue that the demand curve shows the value put on the marginal unit of consumption, and that if this is not equal to the marginal cost of producing that marginal unit then resources can be reallocated to raise welfare: if marginal cost exceeds the demand price then the last

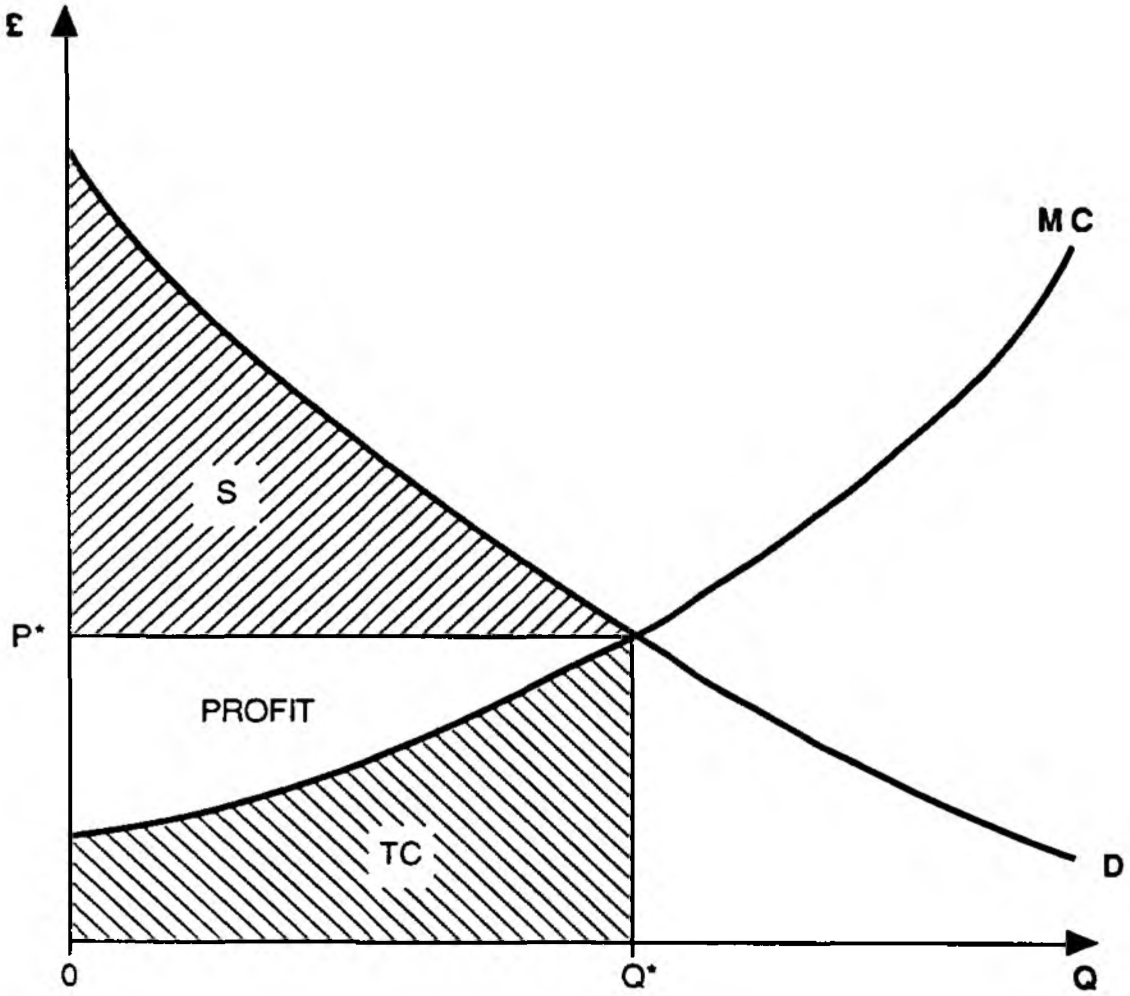

Figure 2.2. Rationale for Marginal Cost Pricing.

unit of the good is costing more to produce than it is worth to the consumer, and production should be reduced.

Thus we have the argument that price should be set equal to marginal cost, standard to microeconomic theory and familiar to a wider audience from the 1967 White Paper on Nationalised Industries (Cmnd. 3437). This laid down two aims for pricing policy: "that nationalised industries' revenues should normally cover their accounting costs in full" (para. 17), and "that the consumer should pay the true costs of providing the goods and services he consumes" (para. 18). The difficulties of achieving both of these aims at once will often mean that more complex pricing schemes are needed. This is the subject of the next section.

2.3 Introducing Complexity

2.3.1 Decreasing Marginal Costs

While the basic solution in the previous section works satisfactorily when the marginal cost curve looks like the one in Figure 2.2, we run into problems if the curve is downward sloping. In that case the average cost curve is also downward sloping, and, more importantly, lies above the MC curve. Thus if price is set equal to marginal cost it will be less than average cost, and the enterprise will not be covering all its costs. This is shown in Figure 2.3, where the shaded area represents the loss that will be made. Decreasing average costs of this sort are particularly common in the public utilities, where there is typically a high fixed cost of the basic infrastructure - reservoirs, filtration plants, distribution pipes and so on in the case of water - and then a relatively small cost of increasing the level of output by a few gallons.

2.3.2 Multi-Part Tariffs

Two main solutions to this problem exist, other than simply making up the revenue

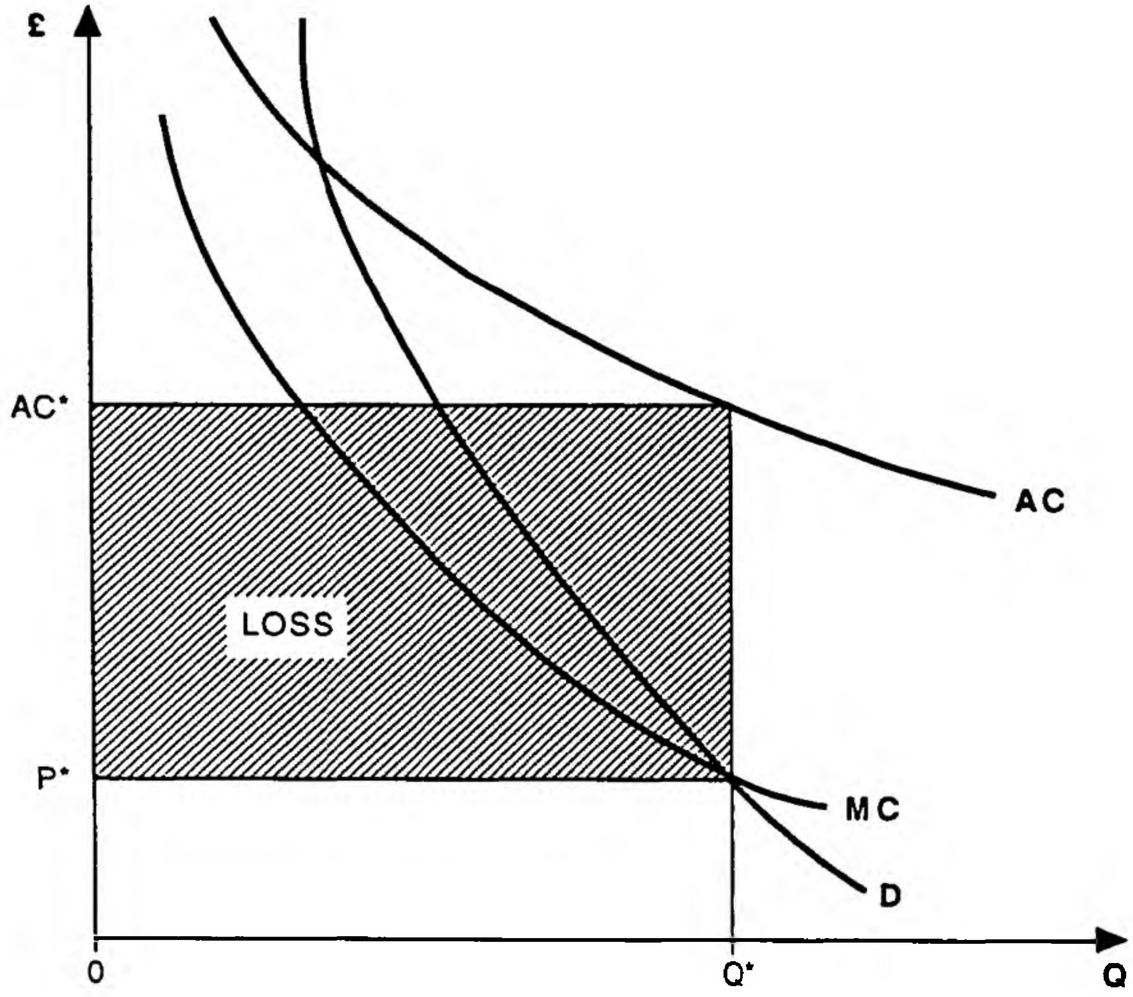

Figure 2.3. Marginal-Cost Pricing with Decreasing Costs.

shortfall out of general taxation. The first is to introduce some more complex form of multi-part tariff, incorporating a fixed or standing charge in addition to the running cost per unit of output. This has typically been the method used in the electricity, gas and telephone industries. It will be particularly workable when the marginal cost is fairly constant over a wide range of output. Once such tariffs have been introduced there is often scope for raising welfare by offering one or more optional tariffs designed to appeal to particular consumer groups, so that the market divides itself up into submarkets.

2.3.3 Ramsey Pricing

A more theoretical solution espoused by economists (for the multi- product firm) is what is known as "Ramsey pricing". This entails raising the price above marginal cost by an amount which is inversely related to the price elasticity of demand for the product. Thus where demand is relatively unresponsive to price the consumer will pay a (much) higher price relative to marginal cost than where demand is price-sensitive. The rationale for this result from a welfare point of view is that it leads to the least distortion of consumption, and therefore production, compared with the marginal-cost pricing solution. Formally it emerges as the solution to maximising the welfare function (1) above subject to a profit constraint (a zero-profit constraint where the requirement is that the firm should break even). The actual result is

$$\frac{P_i - MC_i}{P_i} = \frac{\mu}{1 + \mu} \cdot \frac{1}{\pi_i}$$

where P_i and MC_i are the price and marginal cost respectively of good i, π_i is its elasticity of demand and μ is the Lagrangean multiplier from the constrained optimisation.

This solution depends on being able to identify the different products of the firm, and to keep the markets separate. For the water industry this may well be difficult. Water supply and sewage services are clearly both separate and separable, but water for drinking and water for swimming pools are harder to distinguish: maintaining separate markets for them would not be easy. Good measures of the relevant elasticities are also needed. Finally a more general problem with the "Ramsey Rule" is its equity implications: goods with a low elasticity tend to be those which are necessities of life, and which bulk larger in the budgets of the poor than the better-off. Charging Ramsey prices may thus be politically unacceptable.

2.3.4 Spatial Pricing

The simple marginal cost pricing argument ignores the spatial element of the economy, and this has led to proposals for "mill" or zonal pricing. This is normally thought of in the context of a producer with varying distances, and therefore costs of transport, between his factory and his customers; the question is whether consumers located further away should pay a higher price to reflect the higher total costs of the delivered goods. Charging a uniform price can be argued to amount to spatial price discrimination, with low-cost customers near the factory subsidising those further away. It is perhaps more a problem for the water distributors than for the NRA, as it is they who face the majority of pumping costs; and anyway in practice such zonal pricing "raises issues of equity, administrative expense and consumer acceptance which have made it an infrequently used practice" (Crew and Kleindorfer (1986), page 246). In integrated catchments the rationale for spatial pricing based on capital and operating costs is limited, but clearly the opportunity costs of abstractions can vary considerably depending on the location of the abstractor in the catchment.

2.3.5 Seasonal Variations

More serious in the case of the water industry is the problem of seasonal variations in both supply and demand. Many industries have to face regular or irregular fluctuations in the demand for their product, but few face the problems the water industry does: its supply tends to vary in precisely the opposite way, so that as demand increases in the summer so does supply fall. Problems of this sort from the demand side have led to the development of the theory of peak-load pricing, in both deterministic and stochastic forms.

2.3.6 Peak-Load Pricing

The traditional peak-load pricing theory was developed for products which are not economically storable and for which demand fluctuates over time in a predictable way; electricity is the most usual example. The important feature is that the capacity needed is determined by the peak demand, and pricing should reflect this. Peak-load pricing will of itself tend to reduce the peak. Whether it also shifts demand to the off-peak period(s) depends on the time-scale involved: if the cycle is a daily one (as for Economy 7 electricity) some shifting is probable, whereas if it is a seasonal variation there is likely to be less scope for substitution between, say, summer and winter.

The original theory considered the case of a daily cycle with two sub-periods, with the demand curve for the peak period lying wholly above the off-peak curve and the two demands being independent of each other. The solution is to set a price equal to short-run marginal cost in the off-peak period, and a price equal to short-run marginal cost plus the costs per day of providing an extra unit of capacity in the peak period. However if the demand curves are relatively similar this solution may give rise to the so-called "shifting peak" problem, in which the lower price in the off-peak period leads to this becoming the peak period. In this case both sets of users must contribute something to the capacity costs; the closer the demand curves the more equal the charges.

Matters become more complicated when there is a significant stochastic element in demand over and above the predictable seasonal variations. How much water is demanded for garden watering in a particular summer depends on the weather, and this cannot be predicted with certainty. Moreover it is unlikely that it will be optimal to have enough capacity to meet any likely demand, so some form of rationing will be needed from time to time, and reliability of supply becomes an issue. What method of rationing is used will also affect the level of social welfare achieved. The following conclusions are based on the discussion in Crew and Kleindorfer (1986).

The deterministic model can be extended fairly simply by adding a random error term to the demand equation and changing the objective to the expected value of the traditional welfare function, although this procedure does make certain rather strong implicit assumptions about consumers' attitudes to risk and reliability. Optimal pricing then entails marginal-cost pricing rules of a similar sort to those obtained under certainty, but the appropriate marginal cost is now the sum of expected marginal operating and rationing costs. A peak-load pricing policy remains optimal.

Different rationing schemes are possible, ranging from costless rationing according to willingness to pay to a random "first come first served" form. In general the less efficient the method used the more weight will be placed on normal price rationing to clear the market - that is the higher prices will be. Reliability constraints may also then act as a surrogate for rationing costs. Finally it is worth noting that the type of uncertainty assumed also has a significant effect on the results, with a multiplicative form producing higher prices at the optimum than an additive one.

2.3.7 Peak Loads with Storage

Problems of peak-load pricing have generally been treated separately from those of optimal storage. Riley and Scherer's 1979 paper brings them together by analysing the case of fluctuating demand and supply for water over a (yearly) cycle when there is a storage reservoir available. The marginal operating cost of water supply is basically the cost of purification. The authors' approach is a constrained optimisation one, maximising the net social gain - defined as the area under the inverse demand curve, less costs, integrated over the cycle - subject to constraints on flow (due to purification capacity) and stock (reservoir capacity). The model is in continuous time, and the shadow prices of extra capacity therefore vary too.

The two (linked) policy variables of interest are the price of water and the amount of water in the reservoir, both as functions of time. The argument is centred on an example showing what happens when demand and supply are approximately 180 degrees out of phase. The main result is that price is actually constant except when the reservoir is either full (in the spring) or empty (in the autumn); price rises to the summer level during the former period and falls to the winter level during the latter. Thus in practice a close approximation to the optimum can be achieved by just two prices, one for summer and one for winter. A third, higher price is also needed to cut the top off the peak demand if there are significant purification capacity costs.

Three main points come out of the introduction of storage in Riley and Scherer's paper. The key one is that water becomes a potentially "scarce" resource throughout the year, as even if supply temporarily exceeds demand there is usually the alternative of storing the excess for later use. The other two conclusions are not unexpected: storage leads to a reduction in fluctuations in supply, and the fact that storage is costly means that it should not be increased beyond the point where its marginal benefit equals its marginal cost

2.3.8 Weather-Dependent Pricing

A more complex form of pricing than a simple summer-winter differential is discussed by Lane and Littlechild in their 1972 paper on weather-dependent pricing. In their model the value, and therefore the price, of water for irrigation depends on the level of rainfall that occurs during the growing season; the price schedule is announced in advance, with a set of prices conditional on rainfall levels. In the authors' numerical example, and probably in practice too, the possible "states of nature" are reduced to a relatively few broad categories: here Very Dry, Dry, Wet or Very Wet.

The basic sequence is: announce the conditional price schedule, plant crops, observe the weather, and supply the necessary irrigation water. Lane and Littlechild consider two versions of the model. In the first the irrigation requirements for each crop are fixed once it is planted, and in this case it turns out that a weather-dependent pricing scheme is not in fact required: it is just as efficient to charge a single predetermined average price. In the second variant on the model each crop, once planted, can be irrigated according to a number of patterns, depending on the availability of water. In this case different prices for different rainfall levels are needed. Lane and Littlechild's numerical example for this version produces a rainfall-dependent price schedule ranging from $2.41 per acre-inch of water in a Very Dry season to a zero price in a Very Wet season. The example also suggests a gain in benefit of about one third compared with charging a simple average price.

The authors themselves admit their model is relatively simple, with only one major decision point at the start of the season and a fixed supply of supplementary water available from a reservoir (i.e. not itself dependent on the rainfall). However as they point out there is a tradeoff between the benefits of a more responsive price system and the informational costs it gives rise to. Nevertheless the principle of weather-dependent pricing remains a useful one.

2.4 A Second-Best World

2.4.1 The Second-Best Problem

Much of the foregoing discussion relies implicitly on the assumption that prices, outputs and so on in the rest of the economy are "right", so that we can attain an optimal solution. However this is unlikely to be true in practice, and this gives rise to what is known as the "problem of the second-best". What this amounts to is that if there are undesirable features in the rest of the economy (such as monopoly power, or taxes, or uncertainty) then it is no longer necessarily true that marginal cost pricing and the other rules discussed above will lead to the best possible solution. The simplest example of this problem occurs when a publicly-controlled enterprise is facing a private competitor, and the latter is, for example, pricing above marginal cost; in this case it may well be best for the public enterprise also to set its price somewhat above marginal cost.

How important an issue second-best is will depend on the circumstances of the particular industry we are interested in. The NRA does not have any direct competitors whose behaviour might influence its own, and in general monopolies elsewhere in the economy can probably be safely disregarded, with the important exception of the Water Service Companies (see below) as any interaction will be slight. However there are two factors that do need some consideration in the present case: "flowthrough" and incomplete information.

2.4.2 Flowthrough

The former is discussed at some length by Brown and Sibley (1986), and refers to the situation where the industry of interest sells to other industries as well as to final consumers. This clearly applies to the NRA, which sells water to the water supply companies who sell it on to the general public. Clearly the pricing policy of the

NRA will affect the prices ultimately charged to the private consumer. How important this is depends on the particular features of the downstream industry, but Brown and Sibley focus especially on determining conditions in which decision rules can be established which do not need to take explicit account of the subsequent stages in the production process.

Unfortunately such "myopic" rules apply best in conditions that do not apply in the NRA case: when the other industry is a basically competitive one with free entry. The monopolies held by the water distribution companies in their own areas mean that the NRA will not be able to ignore the subsequent effects in its own pricing decisions, and this increases the amount of information the NRA will need. It has to be borne in mind that NRA 'customers' operate in sectors with very different competitive characteristics. The behaviour of irrigators for example, who have to work in a broadly competitive market, could be markedly different from the reactions of monopolistic and imperfectly competitive utilities or industrial concerns.

2.4.3 Incomplete Information

This brings us on to the second cause of second-best problems mentioned above: incomplete information. Clearly optimal decision-making in general requires a full knowledge of all the relevant costs and benefits of different actions, as well as how other agents in the economy (especially downstream firms) make their decisions. This is something that the NRA - and everyone else involved - does not have.

2.4.4 Common Costs

One area of particular problems is likely to be that of common costs. Any suggestion of pricing at marginal cost, or any other cost, requires accurate estimates of what those costs are, and this is a well-known problem where total costs are common to several activities. How much of the cost of maintaining a certain level of flow in a river, for example, is due to the need to provide enough water for abstraction further downstream and how much is due to environmental considerations? These two outputs are produced together, and the various methods of allocating the total costs between them generally include sufficient arbitrariness to ensure that they are largely accounting conventions. Such figures cannot be used to ensure efficiency.

2.5 Lessons from the Theory

2.5.1 Summary of Classical Economic Approach

The basic rule that emerges is that prices should reflect marginal costs, and would ideally actually equal them. Production is thus increased until the marginal unit is valued at just the incremental cost it gives rise to. Costs are to be interpreted as opportunity costs, so that resources are used where they are most valuable. Where costs can be assigned clearly to a particular group of consumers they should be covered by the prices charged to those consumers. Among other things, such groups may be distinguished by the time or place of their consumption. Costs in the water industry vary considerably from place to place, but this argument is probably most important in the case of peak loads, where the additional costs (of increasing capacity) may be very large. If costs vary at different times of the year, or demand at constant prices does not match supply, then price differentials are needed to generate rational behaviour and economic efficiency. In this way a "first-best" solution can be obained, but it rests on a number of assumptions. These include:

- the focus is on economic efficiency: issues of equity and distribution are not generally being considered;
- the world is one of perfect competition, with full and freely available information, no monopolies and so on;
- consumers are rational and well-informed, so there are no problems of public

understanding or acceptance of economic solutions, and costs of implementation can be neglected.

2.5.2 Conclusion

We may have to diverge from the "price at marginal cost" rule if there are imperfections elsewhere in the economy, or if increasing returns to scale would generate a deficit (although imposing a break-even constraint will generally reduce social welfare). Other than for equity reasons, however, we would never want price to fall below marginal cost. In the event of problems like these we may be led to the use of techniques such as multi-part tariffs or Ramsey pricing to achieve a "second-best" solution, and the rules become more complex. Once we start to use multi-part tariffs, for example, there is likely to be scope for improving welfare by introducing further optional tariffs. We also need to consider what happens downstream of our industry - what Brown and Sibley refer to as "flowthrough". If the industries the NRA sells to are not competitive - as they are not in the case of the public water supply companies - then the NRA's pricing rules should take this into account.

Even without these difficulties there is also the practical problem of determining what marginal and other costs actually are in an industry where joint or common costs are important, as is likely where water levels in rivers are maintained for several different reasons. Distributing the total costs among the various activities is then at best an inexact science.

3 EFFICIENT CHARGES AND PERMIT TRADING SYSTEMS

3.1 Types of Charge

Basically there are three different types of charge - access, availability and actual use - which would be levied in an efficient charging scheme. Ideally they should be employed together to capture different elements in the cost of water provision.

3.2 Access Fees

These are one-off and/or annual fixed payments for a licence to abstract water. In theory, access fees shoud be employed as *one* element within an efficient tariff structure and designed to recover the non-consumption related costs imposed by the abstractor on the regulatory agency. Such costs fall into two categories

(a) 'one-off' - the initial administrative/legal costs of issuing the licence, investigating the hydrological situation, meter installation etc.

(b) 'continuing' - monitoring licence conditions are met, meter reading, charge collection.

Although these access costs could vary slightly for every abstractor, no practicable charging regime could take account of such variations, but differential payments could be requested from the various user groups (household/farm supplies, irrigation, industry etc) based on the average costs imposed by each consumer class.

3.3. Availability Charges

3.3.1 Marginal or Opportunity Cost Basis

These are charges based on the quality of water *authorised* under the abstraction licence. Theoretically these should be related to the *opportunity costs* imposed on the water resource system by 'reserving' a supply for the licence holder. If, as will normally be the case, supply capacity can be increased, then an *extra* unit of authorised abstraction should be priced at the marginal capital cost of supporting or augmenting abstractions plus any external costs associated with the capacity expansion (environmental losses resulting from reservoir construction, for example).

However, if supply enhancement is not physically (or politically) feasible at least in the short to medium terms, then it may be necessary to set the marginal unit price to reflect the losses incurred by other abstractors and 'in-situ' water users in foregoing a proportion of their usage. Such loss calculations would only be necessary where it is not possible to unit price all supplies for all purposes. Where full unit pricing was implementable, efficiency would be served by ensuring that the price for the last unit of water abstracted or employed 'in-situ' was the same for *all* users. As discussed previously, ignoring the ability to pay question, each user would then derive equal value in use from their marginal utilisation and it would be impossible to increase the total welfare derived from the available resource by reallocating some supply units between users. In the NRA case, supplies taken for wildlife protection, recreation and navigation would be difficult, if not impossible to unit price; thus pricing based on damage or opportunity costs suffered by other water users becomes appropriate.

3.3.2 Demand Choking or Rationing

Alternatively, where the minimum allocation of supplies to non-abstraction users has been determined on political or environmental criteria, then prices can be used in a fixed supply situation simply to choke off demand. Unit prices can be raised until a demand/supply balance has been achieved. This will be efficient in the sense that only users with the highest value in use will continue to seek authorisations for the now highly priced units, However, clearly such a strategy raises key equity questions and also ignores the monopoly power of some abstractors, most obviously the water companies. In addition, unless good information on demand elasticities is available, then 'trial and error' price rises may take some time to achieve the required supply/demand balance; moreover subsequent price changes will be necessary to maintain this balance as demand conditions alter over time.

3.3.3 Seasonality

The development of efficient availability charges is inevitably significantly complicated by the seasonal variations in both the supply of, and demand for, water. In essence, for surface waters, supply provided at peak demand/low flow periods is an entirely different product from that made available during high flow periods. As far as many surface water sources are concerned, the unit capital cost incurred to serve winter abstraction demands is zero. Indeed, there could conceivably be cases where non-return winter abstraction could positively benefit the NRA by reducing potential flood flows. The zero cost situation would not, however, arise if winter abstraction inhibited reservoir (or aquifer) recharge, which it could well do in dry winters in some catchments. Where winter abstractions merely reduce the potential supplies 'lost' to the sea, economic logic suggests that no availability charges are levied. This means that *all* the long run marginal costs of supply enhancement should be allocated to summer abstractors. Further, it would give false cost information to users if all year round abstractors paid a lower rate for their summer consumption than summer only users. Such lower rates are frequently justified on the grounds that constant 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.

Where winter abstraction from surface water does reduce the supply potentially available to meet peak dry flow demands, then winter availability charges are economically justifiable. A proportion of the long-run capital costs involved in supply augmentation needs to be allocated to winter users. This proportion will vary with the loss of summer use potential. In an extreme case where winter use of 'x' million litres simply reduces potential summer use by 'x' million litres, then winter and summer charges should be equal.

The extreme case for surface water abstractions tends to be the norm as far as ground water is concerned. For most aquifers it will be irrelevant when the abstracted supply is actually taken; it is the total amount abstracted over the year(s) which affects future resource availabilities. This suggests that ground water availability charges should not vary with the seasons.

3.3.4 Return Flows

Efficient tariff design is further complicated by the question of return water flows. As far as winter abstractions are concerned the proportion of supply returned to the system will not normally be relevant. This applies to both surface and ground water sources. Little ground water is returned to source but rather is discharged to the rivers where it simply increases the loss of potential supplies to the sea. Therefore, all winter ground water abstractions should attract the same availability charge, irrespective of the proportion returned. The only exception to this would be the extreme case where winter surface flows are needed to recharge reservoirs (see above).

The summer abstraction case is much more complex, since the proportion returned, its quality, the position of the return in the catchment, the nature and the quality of the receiving water and even the time of day that return occurred could all affect the opportunity costs imposed by the abstraction. If we simplify the situation by ignoring the location, quality and timing of the discharge and by assuming that all the returned flow is available for reuse, then the pricing problem is easily resolved. *Only* the consumed water units should attract the availability charge. Since all the long run marginal costs of supply augmentation are placed on such consumed units, the implication is that marginal unit charges would be very high. Consumed units would include those incorporated into products, evaporated or returned to estuaries, the sea, or to other points in the catchment(s) where reuse, even for 'in-situ' purposes, is not required.

In reality the quality of the returned water cannot be ignored. Polluted returns will not only impose opportunity costs by utilizing the assimilative capacity of the receiving waters but may also have limited reuse potential, except for such quality-insensitive purposes as navigation. The value to other water users of reduced quality returned flows will clearly vary enormously, which means that attempts to calculate appropriate abstraction charges will be highly complex. Notionally, any return flows of diminished quality should attract a charge equal to the difference in value to other users of the water at its pre- and post-abstraction qualities. Virtually every abstraction would attract a unique 'diminished value' charge. Clearly the administrative costs and the information requirements needed to implement such a charging scenario would be very high and would probably far outweigh any resulting efficiency benefits.

3.3.5 Reliability

If we think of water abstractions not as a single product but as several with different reliability characteristics, then it is possible to vary the authorisation charge with reliability. The marginal capital cost of augmenting supplies to allow an authorized abstraction to take place in a 1 in 20 year drought will obviously be much less than that involved in safeguarding against a 1 in 50 year drought. Theoretically, at least, abstractors could be faced by a range of unit charges depending on the reliability involved. Those users producing high value products and demanding considerable supply security would opt for the more reliable products. Conceptually it would be possible, even within one catchment, for abstractors to take different products, although clearly considerable administrative costs could be incurred in monitoring to ensure that a particular user only took supplies in the years and quantities specified in their authorisation.

3.3.6 Location of Abstraction

The location of abstraction raises no new issues of principle. Charge variations by location are justified to the extent that opportunity costs of the abstraction vary spatially. 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. Where inland catchments are integrated as part of a regional supply network, it would be economically rational for all abstractors to bear the same basic availability charge. The costs of supply augmentation in one part of the integrated system will benefit all users. However, where catchments or ground water sources are isolated, the long-run marginal cost of supply will be unique to these specific sources. It is sometimes argued that the abstraction charge should be varied with the quality of water in inland rivers. Although it is true that the value of the abstracted water to the user may vary with its quality, this will affect the price abstractors are willing to pay for the supply, but it *need* not change the marginal cost of supply augmentation. It is this cost which is the relevant basis of charging. There are, of course, cases where additional relatively low quality supplies could be provided at a lower cost than high grade supplies; for example, sewage works effluent could be diverted to augment flows. In such cases a price differential would be justified by the cost differential. Source quality *per se* does become a more relevant issue when supply enhancement is not feasible (see above). This arises since more 'in-situ' uses can be supported by good quality stream courses, therefore the opportunity costs (or damage) potentially imposed by an abstraction are likely to be greater.

3.4 Actual Unit Abstraction Charges

This third element in the theoretically ideal tariff will normally be a relatively minor item. Since the key capacity costs will be recouped through the availability charge, prices for the actual units of water abstracted should be confined to the operating costs of the resource supply system - any pumping costs, for example. However, there are circumstances where more significant actual usage charges could be economically justified. Even when an optimal system of availability charges is in operation, there will be periods of exceptionally low rainfall during which full use of authorised quantities would impose damage and opportunity costs on downstream or 'in-situ' water users. Drought year actual use surcharges, calculated ideally from the damage costs, could be employed to discourage use. Such use surcharges could also be imposed on a more regular basis in overabstracted catchments if it was not politically possible either to revoke authorisations or to charge marginal opportunity cost availability charges for authorised quantities which are not in practice available.

3.5 Tariff Structures

Under a theoretically optimal system of abstraction charges the ideal tariff structure follows automatically from the marginal (opportunity) cost pricing principle. It is at this point appropriate to briefly discuss the question of alternative tariff structures.

3.5.1 Declining Block Tariffs

For public water supplies and to a lesser extent for irrigation waters, a *declining block rate* tariff has been popular. Under this system, the first block of water units is highly priced and subsequent blocks are sold at lower and lower prices. There are five basic justifications for this charging structure, none of which are particularly convincing. First, it has been argued that the supply authority obtains economies of scale by supplying in bulk to large customers. This could be true for some cost elements, for example meter reading and service pipeline provision costs. However, such cost savings should be reflected in access fee differentials not in the unit cost of authorised or actual consumption. Second, it is often claimed (AWWA 1983) that large users normally have a more consistent pattern of year round demand, and therefore, do not impose peak costs on the system. As discussed earlier this is an invalid claim; all customers who use water at peak periods contribute to that peak irrespective of their usage at other periods. Third, declining blocks have been justified on the grounds that industrial and/or irrigated agriculture should be encouraged as part of regional development policy: such developmental objectives would seem inappropriate for the NRA. Fourth, it has sometimes been claimed that declining blocks encourage a more efficient use of water since supplies taken by large, generally industrial, users have higher values in use than water used by numerous small scale irrigators. While the latter part of this claim may be valid, it justifies setting the same marginal cost price for all users, not the creation of a tariff structure which encourages overuse and overinvestment in new source development.

A final justification for declining blocks arises when the long-run marginal cost of supply enhancement is falling and thus is below the average cost of supply. In such a situation the use of marginal cost pricing would result in the supply authority making a loss. To counter this, only the last consumption block is priced at marginal cost, previous blocks being sold at prices which bring in the required revenue for the authority to balance its books. However, the resulting allocation of water is inefficient since not all customers are paying the same price for their marginal units of consumption. To avoid such allocative inefficiencies, any revenue deficits caused by declining long-run capacity costs are probably best met by increasing the access charge (standing charge) element in the tariff.

3.5.2 Increasing Block Tariffs

Increasing block tariffs are today becoming increasingly common for both public supplies and direct abstraction. They are normally justified either on equity or on conservation grounds. As has already been mentioned setting prices at marginal cost for all users inevitably confronts the ability-to-pay question. Very high prices could effectively exclude low income users from the market, and, to the extent that small users tend also to be the relatively poor, increasing block tariffs can act to protect their usage. Such protection is particularly relevant for public supplies where it may be politically and socially important to provide households with a relatively cheap block of water to cover basic health and hygiene requirements. It is also relevant in the abstraction case if the political decision is taken to safeguard the interests of small users, such as farmers.

Furthermore, in overabstracted catchments, where the supply is fixed (at least in the short term) an increasing block tariff, with the highest block priced above marginal cost, could conceivably be justified on conservation grounds. The higher charges should result in a more speedy reduction in usage to achieve a supply/demand balance. In essence, a political decision would have been made which gave the objective of improving the quality of the water environment greater weight than economic efficiency.

A final justification for increasing block tariffs can also be made if the long-run marginal supply costs are rising. Since marginal prices would exceed average supply costs, the NRA would be making a profit from its sale of abstraction water. If such profit making activity was not politically acceptable, then pricing the first blocks below average cost resolves the excess revenue problem. However even if the last block of supply was priced at marginal cost the allocation of factors of production to water augmentation would still fail to be efficient if a large number of consumers had consumptions which failed to reach the marginally priced supply block. Moreover, the allocation of supply *between* users would not maximize total value (see Chapter 2).

3.6 Peak Pricing

The complexities created for marginal cost pricing by the seasonality of supply and demand have been discussed in broad terms (see Section 3.3.3). In a theoretically ideal world, the unit price of water could vary continuously through the years in line with the marginal cost of supplying it. At a minimum the pricing system should be able to reflect the different marginal costs of making supplies available to meet different types of peak demand. Conceptually, supplies provided during the peak season, month, week, day and even peak hour can be viewed as separate water products, attracting distinct prices. In terms of the large scale capacity costs (in developing regulating reservoirs, for example) needed to meet peak usage the total season peak is normally the key determinant of marginal cost. However, the more short-lived peaks could impose additional capital and operating costs if water were to be locally stored or pumped to meet peak demands. In addition, and most critically, the opportunity costs imposed on other water users in the system could rise dramatically during short-term peaks. Clearly 'in situ' users and downstream abstractors could suffer major losses if peak day/hour demands reduced river flows, even though the total supply available in storage was adequate to meet overall season needs.

3.6.1 Simple Seasonal Tariffs

Given that in the real world continuously varying tariffs are likely to be unimplementable for abstraction water, this raises the question of what type of peak tariffs might be appropriate. If large consumptive users exhibit a highly peaked demand, which is the case in some districts where demand is dominated by large irrigators and canning factories, a simple increasing block tariff could go some way to imposing peak marginal costs on users. However, in areas where large users do not exhibit high peak factors, a simple increasing block tariff would not be appropriate; indeed it could act to increase the 'peakyness' of the system. Since the higher charges should reduce the average usage of large consumers (with no marked variations in their seasonal demand patterns), while allowing 'small' users to take quantities during the peak without moving into a higher price bracket, this will automatically increase the ratio of peak to average demand. In such circumstances more complex tariffs directly focussed on peak usage are required.

The simplest of these tariffs merely differentiates between winter and summer authorisations; no sophisticated meters are required and the costs of implementation are relatively low. However, such basic seasonal tariffs do not impose full costs on customers with short-lived, highly peaked demands, nor need they reduce any needle peak problems. Indeed, according to Mann and Schlenger (AWWA 1982), seasonal pricing can actually increase peak load factors. This could arise if spray irrigators curbed their average usage over the peak season but continued to irrigate as normal in extremely dry periods.

Although such a scenario is conceptually possible, no known evidence exists supporting its operation in practice. Evidence, from Australia and the United States where seasonal tariffs are employed by some public water undertakings, suggests that they can act to reduce peak week and even peak daily demands.

3.6.2 Emergency Surcharges

A variant of the basic seasonal tariff - emergency surcharges - could be employed during drought periods of greater severity than that used in the 'design' of the water supply system. For example, under current conditions in South East England and in East Anglia, it is known that winter rainfall has been insufficient to recharge aquifers and reservoirs and that significant water shortages are likely during the summer. An emergency surcharge on prices for actual consumption could reduce demand, although of course, its use could have equity implications. Once again, a surcharge system might act to reduce needle peaks although its basic function would be to curb total use over the summer season.

3.6.3 Needle and Short-Term Peaks

Virtually all tariffs designed to cope with short-lived peaks inevitably involve the use of sophisticated meters capable of recording demand during specific periods. The key question then is whether the efficiency advantages of such tariffs outweigh their implementation costs. The one exception to this is a differential day/night tariff, allowing customers to choose which they wish to pay. Clearly, however, considerable monitoring would be necessary to ensure that those who have only paid for night time use do not cheat and take supplies during the day; high fines would also be needed as a cheating deterrent. Under most conditions it is doubtful whether the administrative costs of day/night tariffs would allow their implementation but they could result in cost savings in the water system as a whole if they successfully spread the load. They could, for example, encourage irrigators to water during periods when evapotranspiration was least, thus reducing the supply needed to meet plant requirements. Likewise, industrial users could be encouraged to shift their abstractions (by building one day, in plant storage) away from periods when natural oxygen levels were lowest. This could reduce the pollution damage created by upstream effluent discharges.

3.7 Tradeable Permits

3.7.1 Reasons for Adoption

The most common reasons for the use of tradeable permits lie in the nature of established water rights and the political/legal difficulties involved in revoking (or charging the full opportunity costs for) such rights. In effect the vested interests in the existing right allocations are 'bought off' by making the rights transferable and allowing established users to profit from right sales. Transferability certainly provides the opportunity to improve the efficiency of water use in cases where the historic development of rights has fossilised usage patterns. Trading should automatically move supplies from lower-valued to higher-valued uses, although imperfections in permit markets make it highly unlikely that full allocative efficiency is ever achieved. One important advantage of permit trading over unit pricing is that the water authority no longer has the problem and cost of having to devise and implement tariffs which go some way towards achieving an efficient resource allocation. The permit market (assuming it works relatively well) will in effect determine the marginal opportunity costs of abstraction water. "A competitive market that sets a market-clearing price directly confronts the potential user with the real opportunity costs" (Howe 1990).

Permit trading is particularly useful when the total supply of water available for abstraction is relatively fixed; new demands cannot, therefore, readily be met by harnessing further supplies. Trading provides the flexibility needed in any allocation system to meet the requirements of new industrial or urban developments and generally respond to changing economic conditions. Where supply enhancement is feasible, the water authority could decide to invest in augmentation when the permit market price suggests that users are prepared to pay the full marginal opportunity costs. Once new capacity exists the authority would seek to recoup its investment by selling new permits on the normal market. However, the problem is that such sales (or even the risk that new permits will become available) is likely to drive down market prices. This problem can become acute given the characteristically lumpy nature of supply augmentation projects. Large additions to supply could greatly diminish the value of existing permits which would not be greeted enthusiastically by established abstractors. It is perhaps worth noting that permit trading does not preclude the water authority from levying some abstraction charges. The market basically obviates the need for availability charges (Section 3.3) but access fees could still be charged, while unit actual use charges could also be appropriate to cover any operating costs or to curb usage in exceptionally dry years.

3.7.2 Establishing the Market Price

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 5). 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 if 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 U.S. 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 3.1 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 Ql and Q2. The regulatory agency (or court) can utilize this

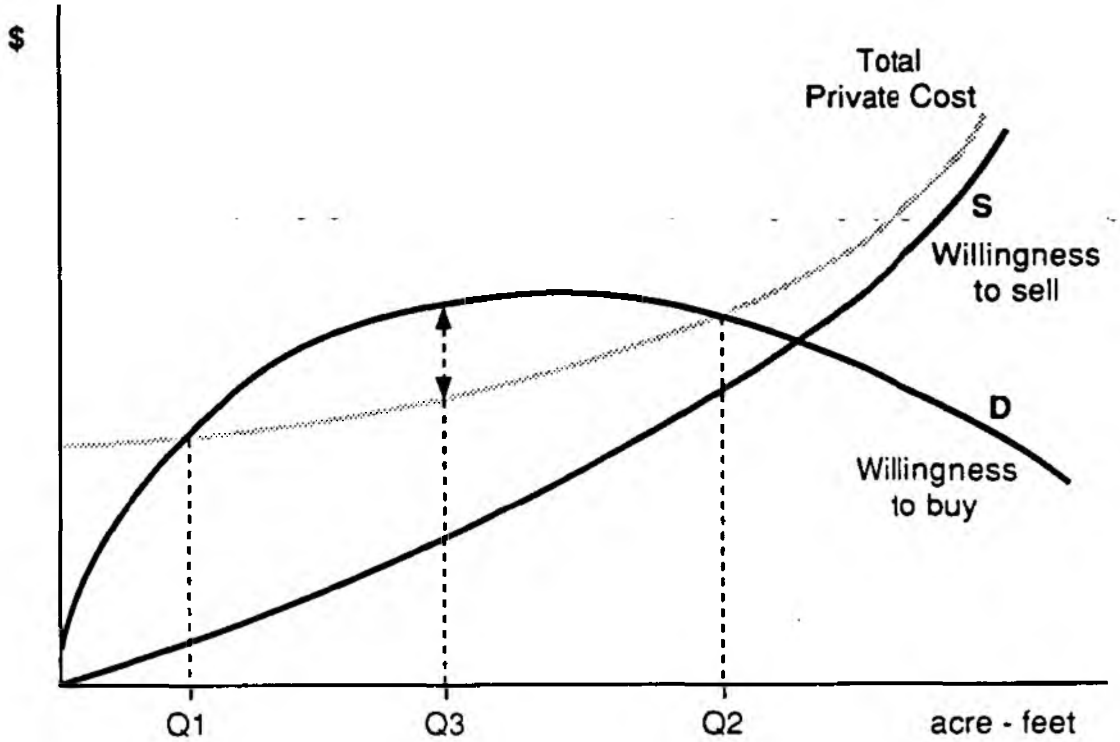

Figure 3.1. The Private cost and benefit case.

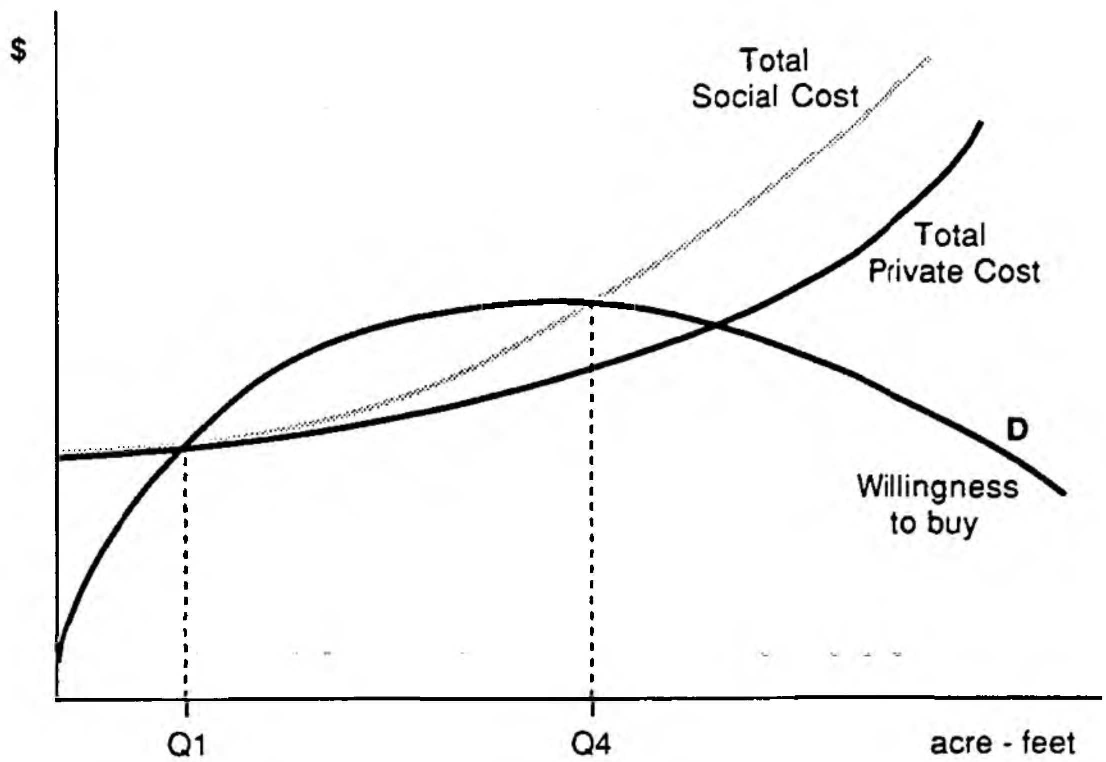

Figure 3.2. The Social cost and benefit case.

information, adding in any external costs to establish whether the sale could yield *social benefits*. As Figure 3.2 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.

3.7.3 Market Imperfections and Practical Problems

A properly functioning tradeable permit system should be able to push water in a more efficient direction and should be able to do so with lower administrative costs than either a bureaucratic allocation regime or a unit charging scheme. In addition the claim is often made that markets can respond much more rapidly than a regulatory regime to changing economic conditions. Moreover, it is argued that trading can effect major reallocations of supply without the political problems which would inevitably be encountered if any governmental agency attempted major redistributive changes. However, in practice a perfectly working permit market is not achievable and there are important reasons for arguing that the perfectly free play of market forces may be undesirable. Imperfections such as the presence of monopoly buyers, high transaction costs and the crucial importance of third party (externalities) effects are all vital in any assessment of the practical potential of permit trading.

Given the environmental responsibilities of the NRA, the external impact of transfers on 'in situ' water uses are of particular importance. In theory, environmental or recreation interests could enter the permit market to buy up rights in order to augment river flows. It would be rare, however, for such interests to play on effective role in the market. Even if all 'in situ' users *taken together* would be prepared to pay enough to buy out abstraction rights, mechanisms capable of harnessing the willingness to pay to numerous, scattered individuals are, at best, poorly developed. In practice, then, a state agency would normally need to retain the power to refuse or set conditions on trades to ensure that the outcomes improve the net *social* value in use of water. However, it has to be recognized that the activities of the regulatory agency could significantly distort the market. If the agency restricted its activities to ensuring that the external costs of a transfer were outweighed by the private economic gains from the trade, then an efficient resource allocation could still result. But if the regulatory agency sought to protect particular 'in situ' interests irrespective of the costs and benefits involved then non-optimal water allocations would be the inevitable result. This has led to the suggestion that public agencies should join the permit market rather than attempt to regulate the trades. If it was thought to be vital that non-commercial fisheries, scenic values or wildlife preservation were protected, then the public purse should be employed to buy up the necessary permits. In other words the State would act on behalf of interests not normally represented in the market. The political feasibility of this suggestion would appear to be low in Britain at present.

As with all market based allocation systems, permit trading depends on the assumption that willingness to pay is a reflection of the value in use which an individual derives from the water. Differential ability to pay cannot in practice be ignored. Large industrial or water service companies normally have the financial resources to outbid small commercial or agricultural concerns. If such large, wealthy users were operating in competitive markets for their products then they would be unwilling to overbid for supplies (i.e. pay more than value in use) but monopolistic or imperfectly competitive concerns need not operate in this way. Given the monopolistic nature of the Water Service Companies there is no guarantee that their permit purchasing policy would conform to the behavioural assumptions of the economic model.

Furthermore, even if all bids did reflect value in use, an 'efficient' allocation which effectively excluded some users, such as irrigators or small family farmers from the water market need be neither socially nor politically acceptable. Likewise, large scale permanent transfers from one area to another could produce economic side effects which were unacceptable politically. Where one activity is an important sourse of local income and employment, a permit sale which benefits the private owner would not necessarily benefit the local community as a whole. Delforce *et al* (1990) have, for example, even argued that the introduction of permanently transferable permits could result in a run-down of local infrastructure where irrigated agriculture is the major income earner in the community. "The mere introduction of transferability would cause the real estate value of those holdings with licences to decrease as that portion of the value of the land representing the value of the water entitlement disappears to materialise as the value of the entitlement itself. The rateable base of the region will consequently decline and local or regional governments will have less funds for provision and maintenance of infrastructure and community services" (p15).

While this is an extreme scenario, and one derived from Australian conditions, it serves to highlight the problem that local economic side-effects are likely to result from a major reallocation of abstraction rights remains. One more basic problem with the introduction of transferable permits arises when a proportion of the existing abstraction rights remains unused. If these so-called 'sleeper' licences are sold, either temporarily or permanently, and then actually used by the new permit holder, over abstraction problems could be compounded. A water management agency can, of course, circumvent this difficulty if actual usage levels are already known; only active licences (or portions of them) would be allowed onto the market. Where actual use is unmeasured a cruder method of resolving the problem is to impose a set reduction factor on each sale. This tactic could also be employed to increase river flows in overabstracted catchments. However, any reduction factor clearly shifts the total private cost (Figure 3.2) and so decreases the scope for beneficial sales.

3.8 Permit Options

Recent research, largely conducted in the United States, has suggested that a variant on the tradeable permit - the option contract - could be used as an alternative to conventional methods of supply management during drought periods (Whittlesey 1986, Gardner 1987, Michelsen 1990). A supply option contract is an agreement between users to transfer water during critical shortage periods; the most usual transfers would be from agriculture to essential urban and industrial uses. In effect, the option contract is a form of drought insurance. Under normal weather conditions the option would not be exercised but in peak demand/low flow years then water transfers would occur. Theoretically, the use of options could curb the development of high cost peak supply capacity. It also has the advantage of giving the option seller a regular income from their water right, which must exceed the productive losses incurred in years when the option is exercised. To date, research on options has been limited to testing the technical feasibility and value of potential peak only transfers. As yet no option contract scheme has been implemented, although the Metropolitan Water District of Southern California proposed buying drought options from farmers in the Palo Verde Irrigation District in Southern California. In the event the payments on offer failed to attract the farmers.

3.9 Permit Auctions

The potential for permit auctions theoretically occurs in two situations:

- when the State already owns all rights to water and has no legal or political need to protect existing users. Such conditions hardly pertain in practice, but conceivably over limited areas, such as irrigation districts, annual auctions could be employed to insure that farmers irrigated efficiently;

- where new blocks of supply have been made available by augmentation works, auctions which permanently transfer the abstraction right could be employed in conjunction with permit trading in order to prevent the fossilisation of existing resource allocations. Alternatively the State can retain ownership and auction rights for limited fixed periods.

In principle auctions operate to allocate supplies to those abstractors with the highest values in use, and if conducted frequently (or used as a precursor to permit trading) they can ensure that resource allocations have the flexibility to respond to changed economic conditions. However, auctions of limited fixed rights offer little security of tenure for established users; their use is thus severely limited in practice. Auctions clearly have the advantage of generating revenue for the water management agency, and in conjunction with permit markets, can help produce an efficient allocation of supplies. But they also suffer from all the equity and ability-to-pay problems discussed earlier. In addition, it is recognised that the nature of the auction itself will influence the efficiency with which the water is allocated.

A basic difficulty is to establish an auction technique which sells supplies at the true marginal value without dividing the available quantity into an unmanageable number of tiny lots. One such technique, which most closely approximates to the economic ideal, is to use the *gold sale* principle. Bids are invited for (say) one megalitre of water and the successful bidder would then nominate the amount to be purchased at that price. To avoid the possibility that the bidder would then take *all* the available supply, the total quantity to be disposed of could be divided into distinct lots or limits could be set on a single purchase. If the original bidder failed to take the full lot, the auctioneer then requests bids for any remaining volumes at the established price. When it is clear that no further bids will be made at that price, the process is begun again and a new price established.

3.10 Conclusion and Summary

All market tools have the potential to improve the efficiency with which water is allocated, but none are problem free. Which particular tool is the most appropriate allocative device is highly dependent on extant socio-economic, legal and political circumstances. A tool employed successfully under one set of conditions will not necessarily be effective, or implementable, elsewhere.

The focus on efficiency as the key management objective leads to a clear preference for charging schemes which reflect the opportunity costs of providing the services, and which thus provide the right incentives to abstractors. Assuming they respond rationally the resulting use of resources should then be optimal. The following are the principal features we would expect:

(a) there should be separate charges for access, availability and use;

(b) the bulk of revenues should come from the availability charge;

(c) the crucial determinants of the price charged for any abstraction should be the quantity, quality, time and location of any water returned to the system. These are what determine the opportunity costs of the water;

(d) it is therefore the quantity of water actually *consumed* that should bear the majority of the capacity costs;

(e) the purpose of use is not relevant, except as a proxy for the quantity and quality of the return flow;

(f) the source quality is not necessarily relevant except where the costs of augmenting poor quality supplies is lower, or in cases where no augmentation is possible when the opportunity costs imposed on other users is higher for good quality sources;

(g) groundwater abstractions should normally attract the same price at all times of the year, as should abstractions from any surface sources where winter use merely reduces summer availability;

(h) prices for surface water abstractions should vary according to season, and could often be zero for winter-only licences. Usage in one season should not affect the price paid in another season.

Charging schemes which adopt these principles will be forward-looking and derived from marginal cost pricing, and should lead to a proper allocation of resources. However, it is also worth noting that even if prices are constrained by being required to only recover costs it is still possible to achieve *some* efficiency improvements by redistributing the charge burden as indicated above.

4. ALTERNATIVE MANAGEMENT OBJECTIVES AND CONSTRAINTS ON EFFICIENCY

4.1 Introduction

Throughout the previous discussion of the theoretical approaches to the efficient allocation of water resources, numerous references have been made to the practical problems involved in implementing economically optimal systems and to the policy goals which need not be served by such systems. In this section these problematic issues will be highlighted and attention focussed on the possible non-efficiency objectives of the NRA, imperfections in the workings of the market, the costs of implementation and the politico-legal constraints under which the NRA has to operate.

4.2. Management Objectives

Before embarking on the use of market mechanisms the first question which must be asked is what overall policy goals the NRA is attempting to achieve. Market based systems are, after all, only tools; their value has to be judged, relative to other allocative mechanisms, in terms of their efficiency, efficacy and effectiveness in allowing particular policy goals to be achieved. Market mechanisms are not a general panacea for all the perceived defects in the water resource allocation system. Although some economists would argue to the contrary, in a case such as water resources markets cannot be a total surrogate for hard political decisions about which water services to provide, for whom, and about how costs should be recouped; nor can they determine what the goals of management should be.

There are at least nine sets of objectives which a resource management agency, such as the NRA may seek to fulfil or be required by Government to fulfil :-

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 resources 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

Further complexity is introduced because a number of these objectives mean different things to different people; this is most obviously the case for distributive equity and environmental protection, as will be discussed below.

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. An economically efficient system is, for instance, unlikely to conform to most acceptable notions of equity; may well fail to serve environmental or community development goals; could conflict with the financial objectives and could also result in public and political dissent. Inevitably, water resources policy is a trade-off process. Different tools of resource allocation (including the various types and structures of tariff) clearly vary in their ability to meet specific goals. Importantly, they also vary in

- the degree to which they are effective taken alone
- the time-span required for implementation and for their impact to become obvious
- the scope for implementation discretion and control avoidance (cheating)
- the level, nature and distribution of implementation costs
- the types of administrative systems and legal arrangements necessary for effective implementation.

4.3 Efficient Tariffs and Non-Efficiency Objectives

In the following sections we consider the performance of efficient tariffs against four of the objectives cited in 4.2, namely financial, environmental protection, equity and community well-being. Throughout reference will also be made to potential political acceptability. This consideration is inevitably of a preliminary nature. Before coming to any final conclusions, work is needed, not only on NRA cost structures to establish what efficient tariffs would look like in practice, but also on values in use and customer behaviour.

4.3.1 Financial Goals

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 redistributing resources is thought to far exceed average costs (see Figure 4.1). 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.

Relatively little thought has been given to the avoidance-of-profit problem in the theoretical literature, in part because profits are not problematic under private sector operations and, in part, because for most public utilities such as electricity or telecommunications long run marginal costs are typically found to be falling . Crew and Keindorfer (1979) do, however, suggest that Ramsey pricing (see section 2.3.3), with a maximum profit constraint, could be employed, or "such a case could also be handled by setting $P_i = MC_i$ and imposing a lump-sum tax to absorb surpluses without introducing allocative inefficiencies". As was pointed out earlier Ramsey pricing has major welfare implications and the notion of the NRA being a contributor to the Treasury through taxation of its profit surpluses is likely to be contentious.

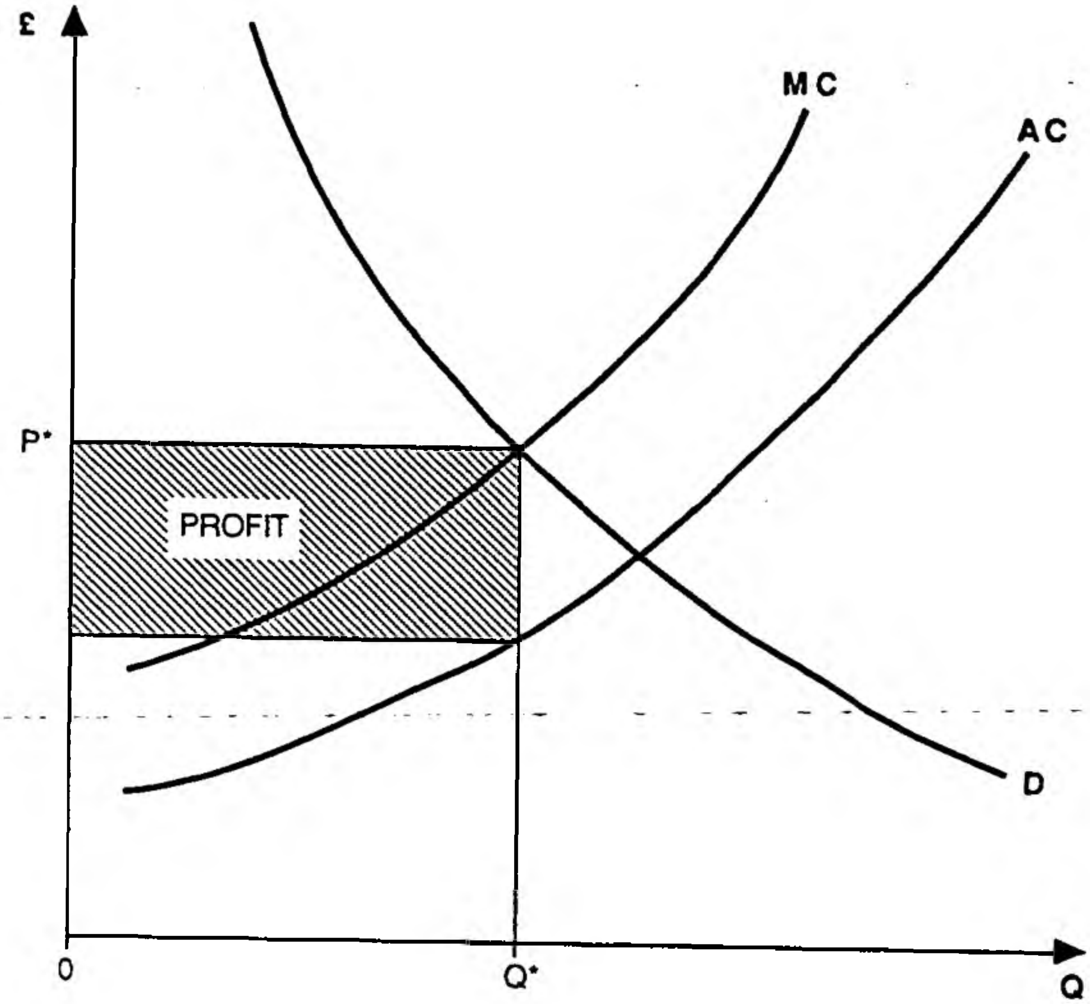

Figure 4.1. Marginal-Cost Pricing with Increasing Costs.

In practice, it would probably be more acceptable to tackle the excess profit problem in two ways. First, access fees could be foregone. Indeed, it is conceptually (if not practically) feasible to consider negative access fees or 'free' water allowances to ensure that the NRA made a 'loss' on the first units of water supplied. However, care would have to be taken to ensure that *all* consumers were still paying the full marginal cost price for the last units of supply abstracted; this will not be a trivial task given the enormous variation in the quantities typically taken by abstractors. Alternatively, the profits made on abstraction could be employed to support water using activities which, by their nature, are not profit making; for example, the support of river flows for environmental reasons and the improvement of wildlife habits. Such a scenario becomes more attractive if a political decision has been made to provide water resources for environmental and conservation interests and not to charge the beneficiaries for these water services. The resulting resource allocation would not necessarily, however, be economically efficient; although abstracted supplies would be efficiently distributed, there would be an effective subsidy from abstraction to 'in situ' users. It is worth noting that such cross-subsidies could conflict with distributive equity if the relatively poor (small farmers, low income domestic consumers paid high water prices to fund the water based leisure activities of the relatively wealthy. Moreover, it is by no means certain that the Treasury would allow this form of hypothecation.

Where supplies are not physically (or politically) augmentable, a somewhat different financial problem arises - namely what to do with the revenue raised by charging the abstractors on an opportunity cost basis. Theoretically, the charges levied on the 'winners' could simply be recycled as actual or indirect compensation payments to the losers. However, while it is relatively easy to conceive of situations where indirect compensation payments could be made (by using the revenue to develop fish hatcheries, improving facilities for recreators etc), it is less easy to see that it would be politically acceptable for the NRA to pay out compensation to private individuals, companies or communities that had suffered opportunity losses.

An efficient pricing system should not raise any significant revenue stability problems, since the payments would predominantly be raised from authorised rather than actual consumption charges. On the other hand, the administrative costs involved in implementing true marginal opportunity cost tariffs are likely to be exceptionally high. Indeed, any attempt to base charges on opportunity losses has to recognise the fact that our ability to put meaningful values on some of the potentially relevant losses is, at best, limited. Administrative costs will be greatest where efforts are made to take full account of the value of return flows and to implement the more ambitious forms of peak tariff (see Sections 3.3.4 and 3.6.3).

4.3.2 Environmental Protection and Wildlife Conservation

One of the major difficulties with this goal is that there is little meeting of minds between those people who see the environment as having *intrinsic* value and those who are concerned with its *instrumental* value (or utility) to human beings. The former group regard environmental or species protection as a goal in its own right; a goal which is desirable irrespective of the costs involved to other water users. The latter group would only pursue environmental protection objectives to the point at which the benefits to human beings from protection equalled the costs involved. No particular environmental state has value in its own right; therefore, from a utilitarian perspective, it would be perfectly acceptable to allow streams to run dry as long as the value in use of the abstracted water exceeded the losses experienced by those with 'in-situ' interests.

If the NRA defines its purpose as achieving an appropriate balance between, on the one hand, extractive and other marketable water services and, on the other hand, largely unmarketable amenity and conservation services, then there need be no incompatibility between efficiency and environmental objectives. However, enormous practical difficulties will inevitably be encountered in evaluating the true social benefits derived from such unpriced (and probably unpriceable) environmental services. In order to achieve an allocative balance surrogate monetary value measures will need to be devised; this is a topic we will return to in a future report. Moreover, even if environmental protection is justified on social benefit cost criteria, the question still arises of who should pay the costs involved. Efficiency would demand that abstractors were not asked to pay charges in excess of marginal opportunity costs in order to fund environmental or conservation services. Rather, such services which could not be attributed to specific interests and priced, should be viewed as public goods, of benefit to the community as a whole, and paid for out of taxation.

Major incompatibilities between economic efficiency and environmental protection could arise if the NRA takes an intrinsic value approach to environmental issues. Clearly conventional economic analysis, and the optimal marginal cost tariffs derived from it, are rooted in the notion of instrument values. There is absolutely no guarantee that a resource allocation which maximises the net social value of water (as measured by willingness to pay) would also protect all those water environments or species regarded as having great intrinsic value by the NRA. Clearly if such protection was judged to be politically imperative economic losses would be incurred and the question of who should pay the costs involved has to be resolved.

4.3.3 Distributive Equity

Equity is an imprecise concept. There are, at least, four different equity notions which could be, indeed have been, employed in the water case to evaluate cost distributions :-

a) consumers should pay according to their ability

b) consumers should pay the same price for the same service

c) consumers should pay according to the value of services to them

d) consumers should pay the costs which their demands impose upon the water system.

Each of these notions produces a vastly different pattern of cost allocation. The last is clearly compatible with economic efficiency, the others are more problematic. Ability to pay has been widely employed as a justification of the rateable value system as a water charging base. Inevitably this concept of equity is incompatible with efficiency; by design it seeks to cross subsidise the consumption of the relatively poor by the revenue generated from the relatively wealthy. In the same way equal payment for the same service conflicts with efficiency unless water is divided into a myriad of different services - each with distinct cost of supply characteristics. As popularly interpreted, however, this notion of equity is used to argue for charge equalisation over regions (or countries), irrespective of the cost of supply differentials. Unless regions have integrated supply networks, there is no economic justification for charge equalisation; although clearly the administrative costs involved in implementing a perfect cost of service charging scheme could outweigh any resulting efficiency advantages.

The third concept of equity - that payments should be related to the value of service within a supply cost category - raises an important conceptual issue. Notionally it should be compatible with efficiency. As was shown in Section 2.1 prices should be designed to ensure that consumers utilize supplies until their marginal utilities (ie. the value of the product) are equated. However, it is conventionally assumed that marginal utilities are revealed by the willingness of individuals to pay for particular goods and services. In other words the marginal utility curves become demand curves. If willingness to pay is not a true reflection of value of service, then the conventional pricing rules could fail to maximize the net total utility of the resource. The fact that willingness to pay is often not a good measure of utility is well known and easily demonstrated. Old age pensioners would, for example, place a very high value on units of fuel needed to prevent them dying of hypothermia, but this value would not be translated into actual payments if they lacked the necessary income. Likewise, a small farmer might place inestimable value on the irrigation water which makes the difference between economic viability and bankruptcy but he may lack the ability to pay such high values. This last example exposes an economic conundrum; value in use to an individual is not necessarily the same as value in use to the economy as a whole. It could well be optimal for the total economy if the farmer ceased trading and released water to those users willing to pay more. But this is hardly consolation for the loss of a livelihood. One way around the problem is provided by tradeable permits; the farmer is compensated for his loss by the sale value of his water entitlement. Notionally unit pricing could achieve the same result but only if the 'profits' from marginal opportunity cost pricing were recycled to the losers; in practice such recycling never occurs.

The NRA is not, of course, a social security department. Conventional economic arguments would place equity considerations outside NRA responsibility, viewing them as the legitimate role of the tax and benefit system. However, it would be possible to devise tariffs which explicitly took ability to pay into account. The basic form of Ramsey pricing, discussed in Section 2.3.3, can be extended to the case where different consumers have different incomes. Then the resulting prices for different goods will also depend on the net social marginal valuation (SMV) of the households' incomes, with this valuation normally assumed to depend inversely on the income level. Where the SMV is generally high for the consumers of a particular good the price of that good will be relatively low, and vice versa; in other words, prices will be higher for goods typically consumed by the rich. More specific results can be obtained if further assumptions are made about the nature of households' utility functions and so on; see Atkinson and Stiglitz (1980), Chapter 12. The authors also point out that increasing equity is likely to be at the expense of further increases in social welfare.

Even if the NRA did not see equity as a key objective, it is unlikely to be able to ignore equity issues entirely. Overseas attempts to change charging incidence have produced two important and basic lessons. First, measures which rapidly and drastically alter the charge burden are politically contentious, irrespective of the economic or equity benefits involved. Consumers, who under the old charging arrangements have subsidised others, are only imperfectly aware of their relative disadvantage, but with any burden change the losers are inevitably aware and frequently vocal. Second, charges which are seen to regressively redistribute real income from the poor to the relatively wealthy are difficult to sustain politically (as the poll tax episode has demonstrated).

4.3.4 Community Well-Being, Employment and Development

It also matters greatly who the losers under any new allocative arrangements are and where they are located. In some Australian states, for example, a mixture of historic sentiment about the role of agriculture in the economy, fears about the social costs of rural decline and the voting powers of the rural lobby made it politically unacceptable to divert water from the agricultural sector, but allowed its redistribution within the sector (see Chapter 5). By and large, political acceptability of a change is easier to achieve if the losers are scattered spatially, sectorally and socially. Unfortunately such a conveniently scattered pattern of loss is unlikely to occur under an efficient tariff structure. Marginal cost tariffs which placed all capacity costs on 'consumed' supply units would inevitably hit hard at irrigated agriculture, certain segments of industry where water was incorporated into products or evaporated, and those water service companies which discharged sewage effluent to sea or tidal waters. The expectation is that charge increases for such groups would be highest in southern and eastern England, where the full marginal opportunity cost of abstraction is likely to be greatest.

If 'loser' clusters do occur then any attempt to introduce efficient tariffs has to confront the problem that improvements in the net utility of water resource use could result in declines in the value in use of other factors of production. In other words allocative efficiency in water utilization could increase allocative inefficiencies in the use of land, labour and fixed capital. This simply arises if high water prices push enterprises to reduce production or to close down entirely.

In theory such spillover inefficiencies should be shortlived as factors of production move to other sectors of the economy where their value in use is now higher. However, this presupposes that the factors of production are mobile, which clearly isn't so for land and fixed capital, such as infrastructure or housing. In addition, in practice labour displaced, say, from agriculture may have few skills relevant to other employment opportunities and may refuse to move to potential employment. Under admittedly extreme circumstances in the United States the reallocation of water from agriculture to higher value industrial and urban purposes has caused significant adverse economic spillovers:

- reduced regional income
- increased production costs for farmers remaining in irrigated agriculture
- reduced rural employment.
- falling real estate values with the knock-on effect of eroding security on loans
- run down of local markets and associated communities.

Although such extreme scenarios, created by transferable permits, are highly unlikely to occur in Britain, they serve to highlight a potentially relevant problem. Namely, the possibility that efficient water resource allocations and tariffs could have significant impacts on particular communities, industrial sectors and employment levels, will almost inevitably impose political constraints on NRA charging policies.

4.4 Imperfections in the Working of the Market

As is well known the market system will only operate to produce allocative efficiency under specific conditions. The most important of these are

- consumers are economically rational beings, able to maximize their utility functions
- producers are also 'economic men' rationally aiming - and with omniscient ability - to maximize profits over time
- all parts of the economy are perfectly competitive, including capital and labour markets
- all factors of production are mobile

- all goods and services are within the market system - i.e. there are no unpriced public goods or externalities
- the economy is free from government intervention.

Clearly such conditions of perfection are never met in practice; hence the need to devise 'second-best' or even 'third-best' strategies under which public enterprises must adjust their behaviour to take account of all the inaccurate resource cost and demand information coming from inefficient 'deviant' sectors of the economy. To undertake all the theoretically required adjustments would require a massive data collection exercise, which in most cases would hardly be justified by the efficiency benefits hypothetically achievable as a result. However, there are three important market imperfections which the NRA should take into account in designing its tariffs.

4.4.1 Non Utility or Profit Maximising Behaviour

Even if tariffs are designed on pure efficiency criteria, the resulting resource allocations may still be non-optimal if water users cannot or will not react to them in the prescribably rational manner. Previous research into user behaviour has shown that the messages being conveyed by highly complex tariffs are often poorly understood,which inhibits efficient response. Likewise abstractors need to have good information about the range of potential water saving measures before they can respond efficiently to price signals. In addition, the responses, particularly of small firms and farmers, may be inhibited by capital shortages if they can neither self-finance nor borrow the necessary investment capital. Such abstractors may continue to pay the high abstraction charges out of revenue rather than making cost effective adjustments to their usage. Non-optimal behaviour could also occur in large multi-plant firms, working under head office capital spending constraints or rapid (commonly two or three years) investment payback periods. Whether these behavioural and information problems are significant in the abstraction case will be tested as part of the field study on overabstracted catchments.

4.4.2 Monopoly and Imperfectly Competitive Firms

The primary problem here relates to the monopoly characteristics of the Water Service and Water Only companies, but the imperfectly competitive nature of major abstractors, such as the power utilities, is also an issue. An efficient pricing system implemented by the NRA will fail to optimise resource use if these abstractors do not respond in an efficient way to the price signals. Water Company behaviour will be crucial. They ideally should devise their own tariffs to convey the NRA's water cost signals through to final water users. Under current charging arrangements for domestic consumers this is clearly not possible. Given such a situation the Water Companies could simply pass the new abstraction costs on to their customers and make little or no adjustments to the level or pattern of their abstractions. In the same way imperfectly competitive utility abstractors would also have opportunities to pass any increased abstraction costs on to their customers, if the demand for their products was inelastic.

4.4.3 Externalities and Non-Marketable Water Services

Ideally externalities should be incorporated into a full marginal opportunity cost pricing system. But there are some externalities which are probably unquantifiable in any meaningful way; aesthetic damage and the pleasure which people get from knowing that particular habitats and species exist (even if they don't wish to see them) may well fall into this unquantifiable category. Ignoring the unmeasured environmental benefits and costs will clearly result in non-optimal resource allocations. There is a case, therefore, for adjusting tariffs to reflect such costs and benefits if they are regarded as significant.

4.5 Conclusions

Tariff design is in reality an exercise in compromise. Any tariff has to be comprehensible to consumers and justifiable on implementation cost grounds. This probably rules out highly complex multi-part tariffs, involving a substantial degree of spatial and temporal differentiation. Tariffs also have to command broad acceptance by customers (and politicians), which means they must be perceived to be broadly 'fair'. Fairness is, of course, a variable and subjective concept, but it tends to imply that abrupt changes in charging incidence need to be avoided; significant price differentials between neighbouring abstractors have to be justified by clear variations in their demand characteristics; and that charge burden reallocations which result in regressive redistributions of income have to be minimized or handled with criteria, if as a result other policy objectives of the Government and the NRA cannot be fulfilled.

5. OVERSEAS PRACTICE

5.1 Introduction

As one would expect from the discussion in the previous sections, no country has a water allocation system which adheres to the theoretical requirements for efficiency. There is no doubt, however, that efficiency is becoming an increasingly important management objective, particularly for countries, such as the United States and Australia, with mature water economies. Increasingly expensive, and limited, new supply options and intensive competition for existing supplies has inevitably focussed attention on the deficiencies of past allocative practices. Even under such conditions it is recognised that efficiency cannot be pursued to the exclusion of other objectives and that new allocative arrangements have to be carefully adopted to suit extant political, legal and economic circumstances.

A distinction has to be made between legal systems which regard water resources as private property and those where Government ownership and control are clearly established. Trading arrangements between private water owners and users will be considered later; attention here is focussed on situations where Government agencies have resources to sell or allocate.

5.2 A Limited Role for Unit Pricing

Although pricing systems are undoubtedly becoming more common, in most countries an abstraction licence or consent is still the primary, indeed often the only, allocative tool employed. Access fees, which have a role to play in an efficient three-part water tariff are frequently the only charges made. In most cases they are purely nominal and barely cover the cost of administering the licence system. Since such charges are flat-rate payments unrelated to the quantity of water authorised or actually taken, they can play no role in achieving an efficient allocation of resources. Conceivably, however, relatively high access fees could deter very low value users from applying for licences. In the absence of volume related charges, the water management agency has to have some criterion on which to distribute abstraction rights. Three criteria appear to be employed - first come, first served; social value of abstraction and distributive equity.

Volume related abstraction charges appear to operate in only seven advanced countries - England and Wales, France, Netherlands, Japan, USA, Australia and Germany (but in only one Land), although legislation has recently been enacted, or is under preparation, to introduce such charges in Spain, Italy and Portugal. A wider range of countries do, however, impose irrigation charges, where a State agency has undertaken the capital works necessary to support an irrigation district. In most such cases these charges are regarded as payment for a product provided (or part payment as subsidies are widespread) rather than as a device to allocate water resources in general.

Apart from England and Wales, no country other than France appears to have a nationally consistent system of charging. The Netherlands may be an exception to this, but the requested details of the charging arrangements are still awaited. Elsewhere, since water resource allocation tends to be a state, regional or local matter, various systems can be in operation in one country.

5.3 France

5.3.1 Agences de Bassin

The French system is based on *actual* abstractions and is administered by the Agences de Bassin. Charges are cost recovery and are relatively low given government subsidies. Abstractors inform the Agences 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 Généraledes 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.

5.3.2 Other Charging Systems

Although the Agences de Bassin may provide supplies for irrigation, separate companies (public and semi-private) can serve this sector and other users within the same district. The Société du Canal de Provence et d'Aménagement de la Région Provencale, for example, provides supplies to 60,000 hectares of farmland and nearly 120 communes (Jean 1980, quoted in Herrington 1987). Agriculture in the area is designated as a 'profession beneficient', which produces a government subsidy of 50% on all elements in the irrigation tariff charged by the Société. The charges are, therefore, much lower than that demanded by an optimal tariff, but the structure of the tariff approximates closely to the economic ideal. Charges are based on the marginal capital costs of supply capacity and support works; they are, therefore, forward looking.

These capacity charges are levied only on *actual* demand during the peak period (3-4 months); off peak usage is free from all capital charges. In addition, the irrigators pay an *authorised* abstraction charge for their peak period entitlement; these charges are based on the replacement cost of the water distribution network. Operating costs are added to the actual consumption charges during the peak period, and are also levied on off peak usage. The system is very close to full marginal cost pricing, particularly as the Société divides its area into supply zones. Zones where the marginal capacity costs are high pay proportionately higher charges - there is no cross-subsidy element involved by attempting charge equalisation.

5.4 United States

In the *United States*, for example, abstraction charges are levied where a River Basin Authority has been created. The Delaware Authority has implemented a simple charging system where the key element is consumptive use. The rate for 'consumed' supply units is 100 times that for used and returned abstractions in the upper reaches of the Delaware River. No charges are levied for abstractions from the saline waters of the Bay and proportional charges are levied in the intermediate zone between fresh and salt water (Herrington 1987).

More normally, however, volume related charging only occurs where state or federal agencies have been involved in major capacity and water diversion projects. The system of charging varies with the agency concerned. The Federal Bureau of Reclamation, for example, has traditionally played a key role in water resources management within the dry western states; it delivers over 30% of California's water supply, for example. In general charges have been designed to recover historic project costs and have frequently failed to do even that. The bureau is required to allocate the costs of a project according to the type of benefit secured. Certain project costs, such as flood control, navigation, fish and wildlife enhancement and environmental protection do not have to be funded from water sale revenue - the costs are borne by the Federal Government. Other uses are partially or wholly exempt from paying interest charges on the capital expended on the project. Whereas the power utilities would normally pay full interest costs, most irrigators would face interest free charges, and industrial plus public supply undertakings are frequently charged interest rates well below the real cost of capital. Clearly political decisions have been made to subsidise particular consumer classes; the rationale for such subsidies is usually a combination of 'ability to pay', regional development and protection for agriculture. In addition to direct Federal subsidies, analyses of Bureau pricing strategies reveal cross subsidisation from municipal, industrial and utility users to the irrigation sector.

Charges are normally levied on a delivered supply basis, with levels of delivery determined by contract between the Bureau and the abstractor. Generally the Bureau retains ownership of any return flows downstream of a water user's property, but this can vary with the specific contract. In the past, water rates were fixed for the life of the contract, and as these could be for over 25 years, it is not surprising that revenues frequently failed to recover even the operating costs of a project. This practice no longer applies, and major problems have arisen when the old style contracts have come up for renewal. Tariff structures can vary with the project, but most have four components

- Storage charge (reimbursable capital costs)
- Conveyance charge (capital, operating and maintenance costs)
- Pumping charge (capital and energy costs)
- Water marketing charge (costs of administering the contracts.

Although attempts have been made to improve the efficiency of charging schemes implemented by Federal agencies, historic patterns of subsidy have proved politically hard to break; the level of subsidy has, however, been reduced since the late 1970s.

5.5 Japan

From the literature it would appear that volume charges in *Japan* are levied on authorised abstractions, but these apply only to surface waters and may not be levied in all river basins. Rights to ground water are acquired through land ownership, although direct restrictions on usage can be imposed where saline intrusion, subsidence or falling water tables are creating problems. According to Herrington (1987), the Yodo basin authority derives its charges from "a tariff matrix which sets out various charges on a per litre per second basis. An annual authorised abstraction which averages out at, say, 400 litres per second would thus produce an annual charge of 400 times the appropriate matrix element". The weightings in the matrix are based on

- type of abstractor-- industrial and mining, municipal supplies and power utilities
- the location of the abstractor according to flow zones
- in one zone only the size of the abstraction, with charges doubled for abstractions over 100 litres/second.

No account appears to be taken in the scheme either of seasonal variations in abstractions or of consumptive use. It is clear that the charging scheme owes more to politics than economics. The weighting system works to ensure that municipal supplies pay virtually no charges, although 'equity of burden' was apparently one objective of the scheme. In 1975, 89% of the revenue raised in the Yodo basin came from electricity utilities, 10% was derived from industry and mining and only 1% was raised from municipal users (OECD 1980). No charges appear to be levied on agricultural users, even though some 70% by volume of all water abstraction in Japan goes to the agricultural sector.

5.6 Australia

Water resource ownership and control are vested in the State Governments. Individuals receive the right to use water through licensing systems, although there are ground water sources (Perth, in Western Australia, for example) which remain unregulated. The period of time over which a right operates varies between the States from one to fifteen years. Conceptually, this system of right allocation should give Australian water agencies considerable powers to ensure efficient resource allocations. In reality, however, past legislation and political decisions have acted to curb agency discretion and considerable opposition is encountered when moves are made to reallocate supplies away from established users or to charge some consumer classes the full costs of their supplies. Transferable permits, rather than volume related marginal cost pricing, have come to be regarded as the most politically and socially acceptable mechanism for improving the efficiency of resource allocations.

By and large volume related charges for direct abstractions have not been levied, except for some overcommitted ground water sources and where capacity developments have had to be made to support downstream abstractions. Such developments have normally, but not exclusively, taken place to serve irrigated agriculture. As with other types of irrigation supplies, prices have traditionally not been set to cover the capital costs of the regulating reservoirs. At best charges recovered, on an average cost basis, only annual operation and maintenance costs. Since the late 1970s some States, most notably New South Wales, have attempted to reduce subsidy levels. In 1982, for example, the NSW Water Resources Commission increased charges from 80 cents per megalitre to between $A3.29 - $A 10.22 (depending on season and catchment).

The new price levels fully cover operating costs and interest charges on capital; they fall well short, however, of recovering even historic capital costs since a proportion of these were paid through direct subsidy. Queensland has also attempted to use the mechanism to tackle over abstraction of ground water zones. In 1978 metering was introduced, and charges levied on actual usage up to a set allocation; price levels were, however, too low to have a significant effect on consumption. More recently, the Water Resource Commission has begun a downward adjustment of allocations; those exceeding the new entitlements pay an excess charge which varies spatially depending on the severity of the over abstraction problem.

Other States, while recognising the need to improve the efficiency of irrigation water use, have shied away from tackling the problems through pricing policies. The Water Authority in Western Australia introduced pay for use pricing for domestic, commercial and industrial users in 1978, with a steeply rising block tariff to promote conservation. But it rejected the idea of introducing a similar system for public irrigation schemes, although in an attempt to curb expenditure the decision was made not to embark upon any new schemes or to augment supplies in existing project areas. This reluctance even to move towards full historic cost pricing for the irrigation sector is understandable, since it would put most farmers out of business and exacerbate the already severe socio-economic problems which exist in rural communities.

Various systems of charging for irrigation supplies are in operation. All are based on authorised abstractions and prices are seasonally differentiated to encourage on-farm storage. However, some river regulation schemes appear to charge for 'ordered' consumption up to a set authorised quantity. Irrigators are supposed to order supplies in advance to enable the appropriate releases to be made from controlling reservoirs; these orders are used to calculate actual and peak use charges. In still other cases, the charges are only indirectly related to volume but are flat rate annual charges calculated from the land area under cultivation, weighted by crop type, application method and season.

5.7 Spain and Portugal

It is known that Spain and Portugal have recently introduced, or are about to introduce, legislation which will allow charges to be made for direct abstractions. As yet no details have been received on the charging schemes in Spain but they are believed to be modelled on the French experience. In Portugal a new Water Law is currently being prepared which will create river basin management authorities with the power to raise revenue from effluent disposal and abstraction charges. The basin authorities will be somewhat similar to the old Regional Water Authorities, except that water supply distribution and sewerage will remain in local authority hands. The charges will be cost recovery; no allowance appears to have been made for asset replacement, and capital costs have been reduced by E.C. subsidies and by low interest Government loans. However, given the level of capital investment required in supply augmentation, water treatment and sewage treatment, the charge levels will be significant.

The currently proposed tariff structure is not dissimilar to those in operation in England and Wales. Charges will be levied against authorised quantities; a unit charge will be set for the whole River Basin Region but weighting factors will be applied to take account of location (zones based on position in a catchment), season, and type of abstractor. The latter will be used as a surrogate for consumptive use. It should be stressed that, to date, only the general principles behind the tariff design are being considered; detailed work on the weighting factors will not occur until the Basin Authorities have actually been established.

5.8 Conclusions on the Practice of Unit Pricing

It is difficult to avoid concluding that the NRA has relatively little to learn about charging efficiency from overseas experience with abstraction charges. The French system as operated by the Agences is broadly based on opportunity cost principles, but government subsidies lower charges and thus militate against efficient water use. Moreover, the charges reflect past supply augmentation costs rather than the long-run marginal cost of supplies. One feature of the schemes is worth noting, however: this is the reported use of highly targetted location weighting factors to discourage use of particularly problematic sources. This practice has potential relevance for the NRA in tackling the problems occurring in over abstracted catchments. In all other countries the charging systems have little to do with economic efficiency. They do, however, serve as a useful reminder that equity, regional economic development and naked political interest have all to be taken into account when devising implementable and acceptable charging structures.

5.9 Marketable Permits (Transferable Water Entitlements)

Transferable permits and the development of permit markets first occurred in the western United States to meet the particular problems created by the traditional water allocation system. The prior appropriation doctrine inevitably fossilised water allocations in patterns to suit nineteeth century socio-economic conditions. Problems were further exacerbated when State legislation tied rights to take water from new state or federally funded storage and transfer projects to the land on which it was used. Legislation enacted in Wyoming in 1909, for instance, provided that "water rights cannot be detached from the lands, place or purpose for which they are acquired, without loss of priority" (quoted in MacDonnell 1990). Given that water rights were private property, any attempt to improve allocative efficiency had either to nationalise such rights or attempt to create markets in which right holders could *voluntarily* sell water (or the right itself) to higher value users. Since the former was politically and constitutionally impossible, water markets were the only feasible way forward.

Logically, permit markets are not necessary in countries where water rights rest in the public domain and abstractors only have an entitlement to use water by Government consent. With State ownership of rights, efficiency can be achieved directly through changes in the prices at which a government agency sells entitlements to take supplies. There is no economic reason why a Government would want to embark upon a permit market scheme, which in effect would have to create new private water rights in order to allow individuals to trade them. However, in the real world matters are significantly more complex; established users acquire interests in supplies which may become politically inalienable; government agencies may lack the information needed to establish efficient prices; efficient pricing schemes may be too costly and complex to administer; and above all efficient pricing may have immediate socio-economic consequences which no Government could countenance and survive in power. For all these reasons permit trading may be an appropriate tool even in systems where water resources are in the public domain; certainly this is the view now taken in Australia.

5.10 Water Transfer in the United States

Water permit sales occur to some degree in all the western states. Most commonly, abstractors transfer water, rather than the right itself, on a short-term, often seasonal basis, within a local area. Such local arrangements have a long history in areas where the law allowed sales and in most cases they impose no externality costs on other water users. A short term transfer system of this type could be appropriate in England and Wales; it would introduce a flexibility in water use not currently possible.

Although in numerical terms less common, in resource utilisation terms far more important are trades involving changes in purpose and/or place of use. These are normally permanent transfers of rights or long-term sales of water under contract. From a recently published study (Water Transfers Working Group 1990), it would appear that almost 6,000 applications for transfer were made between 1975 and 1984 in three western states - Utah (3853), New Mexico (1133) and Colorado (858). Smaller number of applications occurred in Wyoming, Arizona and California. Since the end of the study period it is known that legal and bureaucratic barriers to trading have been eased and that sale activity has accelerated.

The expectation is that such sales would act to shift water from irrigated agriculture to municipal and industrial uses, given the large value in use differentials long known to exist between these sectors (see Figure 5.1).

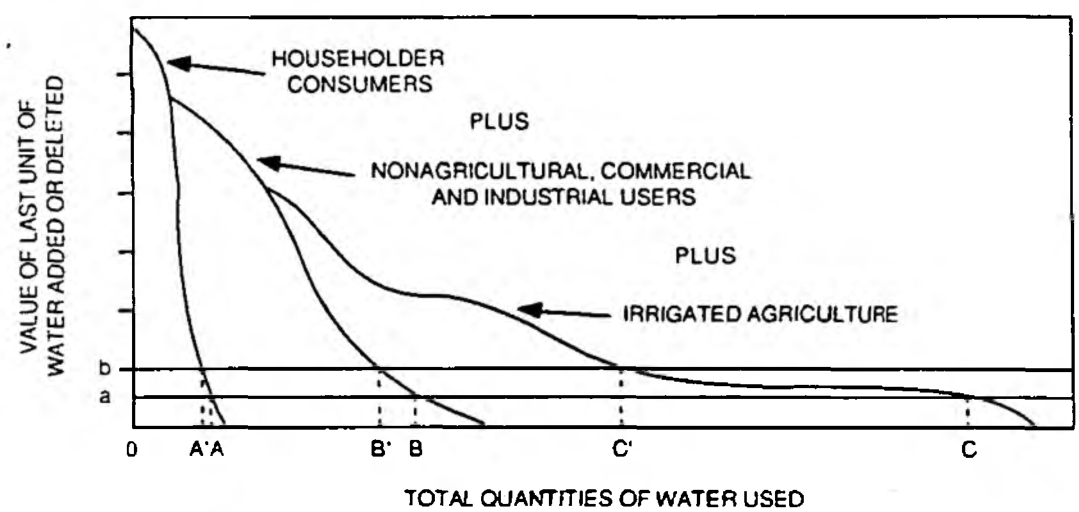

Figure 5.1. Demand Curve For Water For Different Types of Users.

Recent studies (Howe et al 1990, MacDonnell 1990) have, however, shown that the shift in purpose of use was less pronounced than expected. Moreover where such shifts occurred they frequently did not take supplies from the most marginal, least efficient agricultural sectors, but from areas with senior (first priority) water rights. Since such senior rights have historically been applied to the best soils, losses in agricultural productivity can be considerable. Other work (Saliba 1987) paints a more positive picture of the effects of water markets. Saliba found that active markets were relatively efficient in allocating water rights amongst consumptive uses such as agriculture, municipal use and industry. Further she claims that market decisions and prices generally reflected the opportunity costs and compensatory payments to third parties affected by the transfer. However, she did find that market transfers generally did not take into account water quality considerations or 'in situ' uses of water such as environmental preservation or recreational opportunities. Also neglected are the longer term effects on rural employment and income levels.

5.11 Australia

The four southeastern mainland States and Tasmania all now operate permit trading systems in some form and Western Australia is currently reviewing their potential applicability. They are normally known as transferable water entitlement (TWE) schemes. New South Wales first introduced temporary TWE on a State-wide basis in 1983, and a staged programme of permanent transfers is now underway. In the same year South Australia introduced transfers for private abstractors of surface water, and this has subsequently been extended to some ground water sources and more recently to Government irrigation project areas. The other states are experimenting with temporary TWE, but it appears that permanent transfers will be allowed in the near future. Two States, Queensland and Victoria, ban any transfers-out of agriculture, which clearly restricts the efficiency gains from the trading system but reduced political opposition to the schemes and avoided exacerbating socio-economic problems in the already hard pressed agricultural sector.

As Table 5.1 shows, some spatial and volumetric restrictions have been applied to transfers. Some of these restrictions are already politically motivated to project particular spatial or sectoral interests, but others are imposed to improve or safeguard stream flows or water quality within catchments. Most States also have provision for the protection of third party interests but no compensation is paid to those adversely affected by the transfers.

Although most of the Australian TWE schemes are too restricted and recent to draw meaningful conclusions about their long-term effectiveness, most have been judged successful in bringing some allocative flexibility into entitlement systems which had become rigid and inefficient. One important, and unpredicted, problem did however arise and that was the level of 'sleeper' entitlements which were activated by the potential gains from trading. In the North Adelaide Plains area in South Australia, ground water problems were exacerbated by transfers; unused licences normally in less intensively cultivated areas were transferred, so elongating the core of depression and increasing pumping costs to other users. Recognition of the problem has prompted the division of the basin into six management zones with strict limitations on transfer between zones (Boddington and Synnott 1989).

5.12 Conclusions

Trading systems for the allocation of water are not, of course, problem free, but they do appear to have potential in areas where established users have acquired entrenched rights, either legally or by custom. Transferability helps 'buy'

State[1]	When & where introduced	Length of transfers	Transfers between	Spatial restrictions	Volumetric restrictions	Protection of third parties	Special conditions	Agency fee	Price determination
Queensland	1987/88 - Border Rivers 1988/89 - St George & Bundaberg	Permanant - Bundaberg Single year elsewhere	Irrigators only	Within same supply system only	10% of original nominal allocation - Bundaberg. None elsewhere	No explicit provision	Mortgagee written consent - Bundaberg (= for permanent)	In any year, $100 for first transfer, $150 second, $200 third and so on	Negotiated between buyer &seller. Agency maintains register of buyers & sellers for interested parties
New South Wales	State-wide 1983	One-year only; permanency in all regulated river systems in 1989/90	Irrigators only for annual; irrigators and other sector users for permanency	Within set zones of same river system; between systems but subject to channel capacity and environmental limitations	Total allocation transferable; but Ministerial Corporation can impose any limitation on case-by-case basis.	Agency assesses third party effects and refuses transfer if significant. No monetary compensation provision	Must not significantly affect supply channel capacity or environment; conversion between high security and low security supply possible	$75 per transfer for annual; $250 per transfer for permanent	Negotiated between buyer and seller
Victoria	1987/88 - gravity fed districts (Goulburn-Murray, Macalister, Campaspe) & all private (river) diverters	One-year only; permanency expected 1 July 1991	Irrigators only	Within same supply system only	No volumetric limit on irrigation water allocation, but must retain stock and domestic allocation	Agency assesses third party effects & refuses transfer if significant. No monetary compensation provision	Must not significantly affect delivery and drainage channel capacity orsalinity. Written approval of vested interests for permanency	$70 per transfer	Negotiated between buyer and seller

[1] Western Australia permitted experimental ad hoc temporary transfers of water in the 1987/88 irrigation season in the Collie and Harvey Irrigation Districts. However, as yet, there is no formal transferability scheme as such in the State.

Table 5.1. Features of TWE Scheme Implemented in each State.

State	When & where introduced	Length of transfers	Transfers between	Spatial restrictions	Volumetric restrictions	Protection of third parties	Special conditions	Agency fee	Price determination
South Australia	1982/83 - River Murray private diverters 1984/85 - NAP groundwater users 1988/89 - River Murray Government irrigation areas	Permanent from the start; temporary (non-permanent) for any length of time	Irrigators and other sector users	River Murray - to anywhere provided no effect on river. NAP - zoned to prevent transfers to central cone of depression	10% reduction of original allocation if to another irrigator; 70% reduction if to other sector; all allocation transferable	Agency assesses & refuses transfer if third party effects significant. No monetary compensation provision	Must not significantly affect delivery & drainage channel capacity or salinity on Murray & groundwater basin for NAP	$8.50/ML transferred; considering instead set charge independent of amount transferred	Negotiated between buyer & seller. Agency maintains regiseter of sellers for interested parties
Tasmania	1989/90 - trial in Winnaleah Irrigation Scheme	1989/90 year only; future based on trial results	Irrigators only	Within Winnaleah Irrigation Scheme only	No limitation set	Application only approved if considered by agency as in best interest of the scheme as a whole	No privately arranged transfers - arranged by agency only	None charged in trial	Agency balanced water transferred and demand for transferred water. Irrigators transferring gained by not paying annual charges for water transferred

Sources: Results from a survey of State water management agencies undertaken by the Centre for Water Policy Research.

Taken from Delforce *et al* (1990)

acceptance of change allowing established users to profit from relinquishing their entitlement either on a temporary or permanent basis. Purely free markets, however, appear undesirable since they neglect the external costs of transfers. Careful regulation of the markets and regulation geared to the hydrological and socio-economic conditions in particular areas is essential. It is, perhaps, worth pointing out that one advantage of trading systems is that they have markedly improved information on the value in use of water.

6. CRITIQUE AND APPRAISAL OF EXISTING SCHEMES

6.1 Introduction

We turn now to an examination of the ten schemes inherited by the NRA in the light of the discussion in the previous sections. This appraisal will inevitably be of a general nature, identifying the elements in the schemes which are likely to contravene efficiency criteria. A more detailed economic critique of both the current and proposed charging schemes will be possible after the cost disaggregation part of this study has been completed. We should then be better able to evaluate the extent to which the charging factors in the schemes bear a reasonable relationship to the costs imposed by various consumer groups. Additionally we should be able to assess the informational constraints and the transaction costs which inhibit moves towards more efficient tariffs.

In the conclusion to Chapter 3, the basic principles underlying efficient pricing were laid out. While all the schemes clearly make some attempt to differentiate between consumers using broad surrogates for the costs they impose upon the water system, none appear to conform to best possible practice even under a cost recovery constraint.

6.2 Charge types

6.2.1 Access Fees

As was argued in Chapter 3, an efficient tariff structure should encompass three different types of charge - for access, availability and actual consumption - with the second of these producing by far the highest revenue. Rudimentary forms of access fee are employed in some of the regions; 'one off' charges are levied for the issue of impounding licences in Northumbria, for example. However, most appear to confuse the apportionment of costs between access and availability by using minimum charges. Ideally, annual access fees should not exempt abstractors from paying for all units that they are authorised to take. In other words the annual access fees should be a standing charge (section 129 of the Water Act) to cover abstractor related costs, rather than a minimum charge payable in cases where the calculated per unit authorised charge is below a set figure. Wessex (section 14 of the charging scheme) makes potential provision for such standing charges but also has a minimum charge to recover the administrative costs associated with each licence. Elsewhere there are cases where the minimum charge does basically become a non unit related access fee. Perhaps the best example is to be found in the South West Region, where water returned without loss or delay to the same source attracts a factor of zero, but is still subject to a minimum charge; in this case the fixed charge does not offset any other unit charges.

One obvious point to make concerning the minimum charges is the wide variety levied by the regions. If minimum charges are supposed to cover expenditure on NRA management functions (measurement of rainfall, river flows and running the licence system) it is not clear how the charge variations of a factor more than three can be justified. According to the original consultants brief such expenditure is fairly constant between regions, in which case the expectation must be that regions with the largest number (density) of abstractors would need to levy the lowest costs per abstractor to raise the required revenue. From the data available to date this expected relationship does not appear to hold.

6.2.2 Usage Charges

Most regions employ usage charges but only under Section 63 (1963 Water Resources Act) agreements or similar concessions for spray irrigators. Such

	SOURCE OR SUPPORT	SOURCE QUALITY	PURPOSE/ QUALITY OF RETURN	QUANTITY OF RETURN	LOCATION OF RETURN	SEASON	NUMBER OF CHARGES	MINIMUM CHARGE	COMMENTS
ANGLIAN	Surface 1 000 Ground 1 000		Cooling, irrigation 56 250 PWS, other 36 250 High return, SGW, FF 1 438			Summer 1 600 Annual 1 000 Winter 0 160	12*	£9	*Ground sources not seasonally differentiated
NORTHUMBRIAN	Public 1 000 Fresh surface or potable ground 0.300 Tidal surface or non-potable ground 0 060		PWS, spray irrigation 1 000 Industrial, agricultural, domestic 0 600 Cooling, SGW, FF 0 030 Hydro generation 0 002			Summer 1.500 Annual 1 000 Winter 0 200	36	£15	
NORTH WEST	Inland underground 1.000 Some inland, high chloride underground 0 500 tidal (low chloride) 0 100		Spray irrigation 1 000 PWS, industrial, agricultural, domestic, other 0 500 SGW 0 050 Cooling 0 020 Generation, FF, unchanged 0 010				15	£5	
SEVERN TRENT	Impounded 2 000 Reliant on storage 1 000 Unsupported 0.500	Good 1 000 Medium 0.500 Poor 0 250	Spray irrigation, cooling (evap.) 1 000 Industrial, PWS 0.400 SGW,FF, cooling (discharge) 0 020 Water power, heat pumps 0 001			Low flow 2 000 Annual 1 000 High flow 0.200	108	£10	When category of use is not clear use quantity/ quality returned
SOUTHERN			Spray irrigation 1.000 General 0 600 Non-consumptive 0 020			Summer 1.700 Annual 1.000 Winter 0 300	9	£16	Further factor of 0 50 for some tidal sources
SOUTH WEST			Spray irrigation 1 200 PWS 0 925 Industrial, other 0 650 Industrial cooling, no loss 0 004 No loss/delay to same source** 0 000				5*	£16	*Spray irrigation: further factor of 0.75 in certain circumstances ** subject to minimum charge
THAMES	Ground 1 000 Good surface 1 000 Poor surface 0.500		Otherwise 1 000 Direct discharge, medium/low loss, no change in quality 0.100	High (>90%) 1.000 Medium 0.500 Low (<2%) 0 200	Good quality, discharge to tidal, medium/ low loss 2 000 Otherwise 1.000	Summer 2.000 Annual 1.000 Winter 0 200	54	£14.50	
WELSH	Reliant on storage 1.000 Unsupported 0.500	Non-tidal, potable 1.000 Non-tidal, non-potable 0.500 Tidal 0.100	Low return (<10%) 1.000 Medium return (10-90%) 0 800 High return (>90%) 0 600 Cooling high return, SGW 0 100 100% return, no change 0 010			Summer 1.800 Annual 1.00 Winter 0 200	90	£16	
WESSEX			High loss (<70% returned), other 15.000 General - including PWS 10 000 Low loss-cooling etc. 1.000			Summer 3 000 Annual 2 000 Winter 1 000	9	£16.50	Concessions for use of own storage facilities
YORKSHIRE	Inland, non-tidal, 1st class 1.000 Inland, non-tidal, 2nd class 0.700 Underground 0.700 Inland,tidal 0.300		Lost to source 3 000 Irrigation 2.700 Otherwise 1.000 Cooling, SGW, FF 0.090 Returned unchanged 0.020			Summer 1.500 Annual 1.000 Winter 0.500 Held in specified reservoir 0.500	112	£5.50	

Key PWS = public water supply
SGW = sand and gravel washing
FF = fish farms and hatcheries

Table 6.1. Charging Factors for Abstraction Licences.

actual uses charges are clearly non-optimal and it is interesting to note that Wessex specifically excludes such agreements in their charging scheme. It is, of course, appreciated that what amounts to subsidisation of the irrigators *may* be justified on political or community protection grounds, although the costs involved may be considerable. Not only are resources allocated non-optimally but also some of the regional NRAs suffer major revenue stability problems due to the Section 63 agreements. It is sometimes claimed that payment by irrigators of only 25% (or 50%) of the licence fee is justifiable since the reliability of sources frequently fails to allow the full licensed quantity to be taken. This is not a valid justification since the 25% charge will be levied, virtually by definition, in wet years when the demand and supply situation would allow all (or most) of the licenced quantity to be used. Ideally, reliability considerations should be incorporated into the authorisation tariff (see 3.3.5). Actual usage charges, for *all* abstractors not just irrigators, should be confined to the operating costs of the supply system, where these are incurred, and could also be justifiably employed as drought surcharges or to discourage use in overabstracted catchments (see 3.4). All such actual use charges should be additional to, not instead of, the authorisation charges.

6.2.3 Availability Charges

All the schemes raise the bulk of their revenue from availability charges. As was argued earlier this is theoretically correct since the key resource costs are incurred to make supplies available. It goes without saying that the legal constraint limiting charges to cost recovery means that the charges are in general far too low to ensure allocative optimality.

6.3 Seasonality

6.3.1 Summer/Winter Differentials

All but two of the schemes explicity recognise that the season of abstraction for all purposes affects the costs imposed on the water system. The schemes are, however, relatively simple, with just a summer/winter differential: none attempt to go any further down the road of peak load or weather dependent pricing. Both the North-West and the South-West only employ summer/winter tariffs for agricultural users (NW) or spray irrigators; all other abstractors pay the same per unit charge all year round. This is an inefficient practice. All supplies taken during the peak demand or low flow period - irrespective of the individual abstractors peak to average load factor - incur the same additional supply costs. Where seasonal charges are levied, the summer-winter differentials are relatively narrow. It would seem highly unlikely that such narrow differentials go anywhere near reflecting the capacity and opportunity cost variations incurred by usage in the different seasons. Further, it is somewhat surprising that the seasonal differentials are rather similar in the various regions. The expectation would be that differentials would be much higher in those regions (Anglian and Southern for example) where summer supply constraints are greatest. This expection is not borne out in practice.

6.3.2 Annual Year Round Charge

The policy in most regions of having an annual charge for those abstractors taking supplies all year round we would regard as economically unjustifiable. In effect it allows year round users to have supplies in the summer months at a lower per unit charge than other users. This contravenes the theoretical requirement for allocative optimality that all users are faced by the same marginal unit cost. While it is true that year round users do not impose peak *demands* on the system, their demand during the dry season can only be served at a higher unit supply cost. As we have stressed earlier, all users should bear the same supply costs irrespective of their load factors. Therefore, a simple two charging factor system (winter and summer) is to be preferred. Severn-Trent appears to be moving towards this with the provision (p7-8) that the Authority may grant licences and charge for specified quantities in each period.

6.3.3 Season and Source

As was argued in Section 3.6 the resource significance of abstraction seasonality varies with supply source. Only the Anglian and Severn Trent regions appear to *explicitly* recognise this is the design of the charging schemes. In Anglian surface abstractions are charged differentially by season, but this doesn't apply for ground water sources. Likewise, Severn-Trent deem most abstractions from ground water sources to be 'all year round', although it takes a very close reading of a complex scheme for this to become clear! This we would regard as the broadly correct approach. However, since winter use of ground water would normally act to reduce availability during summer, economic logic would suggest that where aquifers are suffering overabstraction use, water should attract the peak season factor. It is recognised that there are cases where winter use would simply reduce the outflow from a 'full' aquifer but this certainly would not be a general situation in southern and eastern England. For some, but not all, surface water sources, the marginal cost of ensuring winter availability is zero; moreover the opportunity costs imposed on other users by winter abstractions would also normally be zero. Therefore, the winter charge factor should be zero. Although it is true that winter only use factors are low, reducing them to zero and increasing the summer factor should provide efficiency gains and provide some incentives for abstractors to provide their own storage facilities. It is important that under current charge regimes abstractors on the year round factor have no incentives to curb peak use.

6.3.4 Source Quality

Under a number of schemes, most obviously Severn-Trent, Welsh and Northumbrian, the effective seasonal charge does vary with source, but the basis for the differentials appear to have little to do with the effect of the abstraction on resource availability. In Wales, for example, unit charges for winter abstraction from surface sources could be significantly higher than those levied for ground water. This arises from the use of source quality and the existence of flow support facilities as weighting factors. Underground sources are classified as unsupported and, therefore, attract a lower charge than a supported surface source, even though the support is presumably designed to provide for summer availability. In this case the use of the factors does not appear to give abstractors useful information about the resource impact of their seasonal abstractions. Incidentally, there appears to be no obvious reason why in Wales ground water should be regarded as unsupported, whereas in Severn-Trent it is classified as 'reliant on storage'.

Finally, in this discussion of seasonality, it is worth pointing out that the definitions of winter and summer vary between the regions. It is not, for example, obvious why in the North West winter (for spray irrigators) begins on 1st November whereas in Yorkshire it begins a month earlier. Nor is it clear why regions have adopted different proportions of water that can be taken in the summer months before the whole abstraction is classified as 'summer' (75% Anglian and 85% in Severn-Trent, for example). Our suggestion of a two factor system would solve the problem; in Anglian's case, for example, abstractors with 75% summer use would pay 75% at the summer rate and 25% at the winter rate.

6.4 Return Flows

All regions have clearly built into their charging schemes the important return flow issue. Most, however, employ purpose of the abstraction (and in some cases time of year) as a proxy for this. How well these proxies relate to reality is, of course, an empirical question, but they are clearly at best crude. We welcome Severn-Trent's approach in cases where category of use is unclear; it is spelt out in the charging scheme that in such cases the quantity and quality of water returned shoud be used in deciding the appropriate factor. Ideally, all factors should be determined in the same way, although clearly the administrative costs involved could outweigh any efficiency advantages.

Most of the regions do not, however, differentiate charges on the *'value'* of the return flows. Winter return flows would normally have negligible value and, therefore, credit for returns should be minimal or zero. This problem would, of course, be diminished if winter abstractions from surface sources were given a factor of zero. The value of summer returns would vary greatly with the location and quality of the flows (see 3.4). While spray irrigators and totally consumptive cooling purposes clearly should attract the highest factors, the case of other users is more complex. For public water suppliers, for example, the use of one (usually relatively high factor) fails to give any incentive to the companies to return supplies to parts of the water systems which could benefit. It would not be an impossibly complex task to devise a system which weighted return flows by location of return; making estuarine and sea returns a totally consumptive use but reducing the factor markedly for upstream returns. Severn-Trent goes some way towards value differentiation in its provision on page 6 of the scheme that allows the Authority to override purpose and place abstractions into 3 categories

i) returned flows to source outside the region

ii) returned flows via the sewerage system to regional supply sources

iii) returned flows without material alterations in quality or quantity if within the region.

It should be stressed that purpose of itself has no relevance for economic charging. Its use in the schemes is only justifiable in so far as it captures the key value of return flows. Consumptive uses should only be charged if the quality or location of return reduces the value of water to the river system. Given that the NRA is now a national body, the justification for charging more for abstractors who return the flow to locations outside the source region is unclear (see Seven-Trent for example). From a national perspective such out of region returns could have very high resource value.

6.5 Source of Supply

6.5.1 Tidal Sources

All but three regions have charge differentials based on supply source. This is clearly justifiable when the opportunity and marginal long-run costs of supply vary with source. Tidal (or estuarine) abstractions should, for example, normally attract a zero weighting factor. While some regions do exclude such sources from their schemes, it is not clear on what basis the low, but still positive, factors employed in Northumbrian, North West and Yorkshire could be justified. If their use is simply meant to recover the costs of administering the licence system and hydrological monitoring then such costs should be included in an access fee unrelated to authorised quantities.

6.5.2 Water Quality

Where the schemes differentiate inland sources on the basis of water quality, the economic issues become more complex. As was discussed in Section 3.3.6, there need be no simple relationship between the marginal cost of supply augmentation and the quality of the source. Under an ideal long-run marginal cost pricing system, source quality would only be relevant in so far as lower quality supplies could be augmented at lower cost. It is, of course, feasible that the marginal supply costs do vary markedly for different quality grades, but this needs empirical verification. However, if the charges were to be set to allocate a *fixed* supply between competing users, then quality could be a relevant consideration for different reasons. Where sources of high quality are in short supply, higher charges could simply be seen as a rationing device, designed to choke off excess demand. In addition the opportunity costs imposed on 'in situ' users could be higher for good quality sources, in which case quality differentials could be justified economically.

The suspicion is, however, that the regions employing quality factors do so on the basis of the potential value of the source to users rather than on any supply cost or rationing criteria. Although, from some conceptions of equity it would appear to be fair that those taking a high quality supply should pay more for it, the result need not be an efficient allocation of resources. For example, it is not economically obvious why an isolated abstractor taking supplies from an unsupported river source, without imposing any costs on 'in situ' or downstream abstractors, should pay more simply because the source flowing past the property happens to be of good quality; this is particularly so if the use to which the water is put is not quality sensitive. Further work needs to be done on the relationship between cost (augmentation and opportunity) and source quality before any possible inefficiencies - resulting from the use of the quality factors can be fully assessed.

6.5.3 Supply Augmentation Facilities

In two regions - Severn-Trent and Welsh - sources are differentiated according to availability of supply augmentation facilities. This has a logic in as much as it is an attempt to reflect the different costs incurred in providing the supply. However, given that the factors are backward looking, based on past investment decisions, they may be giving abstractors highly inaccurate information about the long-term costs which their abstractions impose on the water system. We have already noted in 6.3.4 one anomaly that can arise from the use of such 'support' factors. In general, it would be quite possible under such schemes for abstractors to pay low charges for 'unsupported' sources even if the resultant demands caused over abstraction and imposed considerable opportunity costs on other actual or potential water users. We have to admit to being unclear why in the Severn-Trent scheme abstractions made directly from impoundments should attract a higher factor than those reliant on storage. Conceptually at least, the costs imposed on the system by taking supplies from the storage itself should be no different from those incurred by taking supplies released from the same storage. This matter clearly needs further investigation.

At this point it is worth noting a peculiarity in the Northumbrian scheme; public water supply appears in two charging factors, support and purpose, and attracts the highest weighting in both cases. We assume that the scheme arises from the political need to cover the costs of Kielder in some broadly acceptable manner, rather than having any real efficiency advantages. The scheme is apparently driven by notions of equity, with equity defined as consumers should pay the same price for the same service (see 4.3.3); supplies to the water companies being deemed as a different service from those made available to private abstractors. As a result abstractions from the same source at the same time could attract very different charges depending on whether the abstractor was a water company or not. Moreover, charges do not vary with the costs incurred in actually making particular supplies available. The charges booklet explicitly states that 'support' charges will be levied even if the abstraction can be sustained without support.

6.6 General Issues

This last point raises an important general issue. Under all schemes, within region prices are uniform (given the charging factors involved), so that spatial cost differences are not being fully reflected. Under an integrated supply system such spatial differences are not relevant if long-run augmentation costs are the charging base. This does not, however, apply for unintegrated systems, nor does it apply when the opportunity costs imposed by abstractions exhibit marked spatial variations. Clearly spatially differentiated schemes would involve increased administrative costs, but they would enable the NRA to employ the price mechanism to discourage abstractors from employing particular sources where damage or augmentation costs were high.

One obvious difference between the schemes relates to their complexity. While some differences would be expected to reflect the geographical features of the regions concerned, there is no immediately evident reason why the South West needs only five basic charging bands, whereas Severn-Trent has potentially 108. Research has shown that for customers to make an efficient response to any tariff scheme they have to understand it and be able to assess how they can alter the charge burden by adjusting their usage behaviour. Comprehension is not facilitated by complexity, nor is it aided by the language employed in many schemes.

Response is further inhibited by the number of factors which operate irrespective of abstractors' behaviour. For example, industrial users or public water suppliers cannot affect the crucial purpose (reuse) factor by altering the level and location of their return flows. Likewise, abstractors requiring only a low quality supply cannot normally express this demand; to have any water at all they have to take the quality (and bear the cost) of the supply which happens to be occur adjacent to or below their property. Although it is appreciated that the use of general weighting factors affords administrative simplicity, there is a need to consider carefully whether the resulting charges provide abstractors with the correct information and incentives.

Given the NRAs environmental objectives one worrying feature of most of the schemes is their general failure to take resource and environmental costs fully into account. Clearly this problem partly arises from the cost recovery nature of the schemes. This feature obviously explains the anomalous situation whereby standard charges on a per megalitre basis are highest in Northumbria where shortage problems do not exist and are relatively low in Anglian and Wessex, for example, where overabstraction difficulties occur (see NRA Summary of Unit Rates and Minimum Charges 1990). However, cost recovery only provides a partial explanation of the failure. For some regions the role of charges in providing opportunity cost information and incentives to abstractors to alter their behaviour does not seem to be fully appreciated.

This most obviously applies in cases where charges have not been loaded onto peak period abstraction to the full extent possible within the cost recovery constraint. We have already pointed out that the use of the 'year round' sfactor gives abstractors false information about the costs imposed by their summer usage and gives no incentives for the development of on-site storage or other peak use reduction measures. Likewise in many schemes the failure to take account of the location of the return flows and the seasonal variations in the value of any returns does not give the correct incentives to abstractors. Some schemes, most obviously the Welsh, provide detailed lists of river stretches to be included into just two (or three) quality class weighting factors. This seems to us to waste the chance to develop a scheme capable of taking into account the opportunity (including environmental) costs involved in abstractions from different stretches of river.

6.7 Conclusion

None of the schemes are ideal from an economic perspective, even given the cost recovery constraint. In many cases it is thought that relatively simple changes could be made without incurring excessive administrative costs to provide abstractors with better information on the costs imposed by their abstractions. We have outlined some of these changes above and will return to the issue once the cost disaggregation exercise has been completed. Whether the resulting charges will be high enough (given cost recovery) to significantly alter behaviour will depend on the shape of the respective demand curves. As mentioned in Section 1.5, we would like to explore the possibility of developing the 'Herbertson' data base and charge impact model to take account of demand elasticities.

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