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International Development*

— *Edited by Ian Smout*

Effective Demand for
Rural Water Supply in
South Africa



Michael Webster



EFFECTIVE DEMAND FOR RURAL
WATER SUPPLY IN SOUTH AFRICA

Effective Demand for Rural Water Supply in South Africa

Technical and Financial Implications
of Designing to Meet Demand

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*Edited by
Ian Smout*



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Preface

The importance of consumers' demand for water and sanitation has been recognised for some years. For example, in a review of experience gained during the International Water Supply and Sanitation Decade, Cairncross (1992) concluded,

'The principal lesson is that progress and continuing success depend most on responding to consumer demand.'

This perspective and its implications have gained increasing attention in the sector during the 1990s, particularly for water supply, with 'demand-led' projects and the 'demand-responsive approach'. Much of this has been based on the work of economists (for example, on assessment of willingness to pay for services and facilities) and sociologists (for example, on tools to empower communities to make informed choices). Fundamental to the demand-responsive approach, however, are questions which have a strong technical component:

- What are the feasible options for service delivery?
- How much would each option cost (both capital and recurrent costs)?

Engineers are used to designing rural water supply systems using supply-driven principles. Standard consumption rates and minimum levels of service are incorporated in design criteria and used to design systems, which are adequate to meet social or political objectives. Demand-responsiveness, however, requires customers to be given a choice as to their supply, and engineers need to rethink the way in which they design to meet these demands.

In this study, Mike Webster investigates the effective demand for rural water supply in South Africa, considering the application of a demand-responsive approach in order to improve project sustainability. The study was conducted as an Individual Research Project at WEDC in 1998, part of his MSc programme in Technology and Management for Rural Development.

Similarly to many other countries, the South African government subsidises the capital cost of rural water supply, but users are expected to finance the running costs. For consumers to pay these costs requires the supply to match the effective demand, that is, the service which customers demand and for which they are willing to pay at a particular price level. This willingness to pay itself depends on the level of service, for example, whether the supply is from a communal standpost, or from an individual yard tap or from a house connection. Consumers are usually willing to pay more for a better service, which offers the prospect of improving cost recovery and expanding services through designing to meet their demands.

The study examines the implications of designing systems to provide a mixed level of service, where each consumer household can choose their initial type of supply at an

appropriate tariff, and, at a future date, can choose to upgrade to a higher level of service.

The study includes a literature review of demand assessment methods and a case study of water supply options for a typical village in the Northern Province of South Africa. This is used to investigate the technical and financial implications of designing to meet demand. Various scenarios allowing for mixed levels of service are modelled using assumptions regarding initial and future water demands. These show the financial implications for the water service provider, regarding costs, tariffs, subsidy and loan financing.

Engineering principles teach that infrastructure should be designed for future conditions and that designing only for the existing situation results in infrastructure which is soon out of date. Similarly, this study shows that the crucial question for engineering design is not just 'What is the demand at the start of the project?' but rather 'What will be the demand at 5 years, 10 years and 20 years into the future?' This suggests that debate about the most accurate methods of assessing current demand may be missing the point.

While this study was being finalised for publication, the debate about the Demand-Responsive Approach (DRA) has continued. In mid-1999, it was the subject of an international electronic conference (<http://www.oneworld.org/thinktank/water/drarep.htm>). One of the findings was that, in terms of technical feasibility, communities should be presented with a series of options accompanied by honest cost projections, outlining the actual implications in cash and in-kind contributions over time. This case study, however, shows that these cost projections are not straightforward, and go beyond the usual requirements of engineering cost estimates. They depend both on the uptake of the different options, and on tariff policy with regard to cost recovery and cross-subsidy between locations (e.g. within each system or over a region), between types of service (e.g. house connections subsidising standpost supplies) and over time (start up costs covered by future revenues).

The issues raised in this study are now included in a research project being undertaken by WEDC in collaboration with Mvula Trust (South Africa), NEWAH (Nepal), OXFAM (Tanzania), UNICEF (India) and Metroeconomica (UK). This is funded by the UK Department for International Development (DFID) as a Knowledge and Research project, Designing Water Supply and Sanitation Projects to Meet Demand: The Engineer's Role. The project will run from 1999 to 2001 and information and progress can be monitored at <http://www.lboro.ac.uk/wedc/projects/list.htm>.

These recent developments show the high level of interest in the topic of Effective Demand in the water and sanitation sector, and we hope that publication of this study will help to inform and stimulate the debate.

Ian Smout
Leader of WEDC
December 1999

Executive Summary

The South African water sector faces two main challenges in rural water supply:

- serving the 11 million rural people (65%) without adequate access to water; and
- implementing water supply projects in a sustainable way.

The Department of Water Affairs and Forestry (DWAFF) has responded to this challenge by proposing to supply a 'basic level of service' to all South Africans within the next ten years. There is serious doubt as to whether this aim will be realised and as to the sustainability of the existing and proposed projects.

DWAFF policy is to subsidise the capital cost of a communal standpipe supply while communities are expected to pay for the running costs. If recurrent costs are to be financed solely through user charges, this paper argues that supply needs to respond to effective demand. Effective demand for rural water supply can be viewed as the 'willingness to pay' (WTP) for particular levels of service. WTP will vary within communities and in order to respond to this varied demand, a mixed level of service should be supplied. This paper draws on a literature review investigating methods by which demand can be assessed, and considers, using a case study, the technical and financial implications of designing for a mixed level of service.

The problem

DWAFF has made progress in addressing the backlog of supply by constructed systems serving over 1.2 million people over the past four years, however, the sustainability of these systems is under threat. Although DWAFF policy states that users should pay the recurrent costs of supply, payment levels on current projects are negligible. DWAFF cannot continue to finance recurrent costs, as it does not have sufficient budget allocation from the national fiscus. The increasing subsidy burden from recurrent funding is also depleting the funds available for capital development.

The policy and practice of DWAFF is resulting in projects being implemented in a supply-driven approach. Supplying a fixed level of service is not enabling consumers to choose the level of service for which they are willing to pay. This is resulting in inappropriate design and projects not allowing for upgrading. Many communities aspire to a higher level of service i.e. a private connection, and systems are being crippled by unauthorised connections. Institutional arrangements for rural water supply are also inadequate.

Towards better solutions

Water is increasingly being shown to have economic as well as social value. The economic benefits of an improved supply are illustrated by users WTP for the service. If users are required to pay the cost of supply, this economic value needs to be understood and exploited.

The ‘demand-responsive approach’ is an integrated approach to water provision — influencing social, technical, financial and institutional aspects — believed to improve project sustainability. The primary measure of ‘demand responsiveness’ is the degree to which consumers have choices over their level of service. Services should be based on these consumer preferences and charges set to recover actual costs.

Designing to meet demand

Project cycle

Responding to demand requires an overall consumer-orientation of the service provider, however, there are two specific stages within the project cycle where demand-responsiveness is essential to design:

- *identification/pre-feasibility*: the financial (cost recovery principles) and institutional environment (roles and responsibilities of the Water Service Authority, Water Service Provider and the community) needs to be clarified; and
- *feasibility*: communities need to be offered a broad range of levels of service with associated costs and tariffs in order for householders to choose the type of supply they are willing to pay for. Design needs to capture this WTP and enable individuals to upgrade their level of service throughout the project life.

Demand assessment

A literature review revealed that methods of assessing demand can be classified into:

- *direct methods*: where people are asked to state their WTP for an improved supply using hypothetical scenarios; and
- *indirect methods*: where WTP is elicited through other methods.

The contingent valuation method is the most commonly used direct valuation method for water supply projects. It uses carefully designed surveys to ask people to choose the amount they are willing to pay between different supply options. It is useful to inform policy regarding cost recovery and levels of service but does not seem to have broad application for small rural projects. The link between eliciting WTP from the survey and setting tariffs related to actual costs of supply is not clear. It is expensive and time-consuming to conduct and attempts to estimate demand to an accuracy inappropriate to small projects.

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Indirect methods range from measures of the affordability of proposed systems to observation of current behaviour e.g. the amount paid to water vendors. Up-front community contributions to an O&M fund has been found to be an effective indirect indicator of demand. Methods can be used in tandem for increased reliability.

Community participation in the planning, design and implementation of projects will contribute significantly to demand-responsiveness. Demand assessment attempts to predict initial demand for an improved service, however what seems to be more important in the South African context is for projects to be able to respond to demand over the entire project life.

Technical implications

Rural water supply design is an iterative process involving many assumptions. At one level, demand assessment is only useful to the designer in estimating the average water demand. Water demand is influenced by:

- the number of households choosing different levels of service (estimated through some demand assessment technique);
- estimated consumption per level of service (this will need to be assumed from local information or reliable guidelines); and
- change in demand: due to population growth and upgrading (difficult to estimate).

Design will also be influenced by the choice of peak factors, estimations of 'unaccounted for water', and design guidelines. The designer needs to model the sensitivity of these different assumptions to the average daily water consumption. Designing for a mixed level of service, in effect, adds another factor to this set of assumptions.

In order to design bulk and distribution infrastructure, an average per capita daily demand is needed to calculate the capacity required from the system. In a mixed supply, instead of designing for 25 l/c/d (or 60 l/c/d), this figure will need to be estimated from the average consumption of the different levels of service. Different system components need to be designed for different projected demands e.g. distribution needs to be designed for future demands whereas source and storage can be increased incrementally as demand increases. The capacity of the system to cater for households upgrading from a standpipe supply to an individual connection over the project life is a key design feature of a mixed level of service.

Financial implications

Financial issues are best illustrated through a case study. Table 1 presents costs and tariffs of three initial demand scenarios where levels of service are restricted to standpipes and individual connections for a typical village in the Northern Province. The cost of supply enjoys significant economies of scale i.e. as demand increases, costs decrease. Cost are inclusive for May 1998 in SA Rands (1 US\$ = R 5.00).

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Table 1. Mixed levels of service

	Unit	Scenario		
		1	2	3
Base year demand				
Communal standpipes	%	80	50	20
Yard connections	%	15	35	50
House (kitchen) connections	%	5	15	30
Average domestic water demand	l/c/d	39	60	84
Total daily demand (including institutions and UAW) ¹	m ³ /d	99	155	217
Capital cost	R/capita	350	462	553
O&M cost	R/m ³	2.52	1.93	1.60
Possible tariffs (based on typical household size and consumption)				
Standpipe (flat rate based on O&M of basic level of service)	R/house/month	16	16	16
Yard connection (average incremental cost) ²	"	64	55	65
House connection (average incremental cost) ²	"	103	89	105

¹ Village of approximately 1,900 people

² AIC based on O&M + depreciation + capital needed for upgrading (less subsidy); 2.5% population growth; annual fixed rate of upgrading at 4%; and additional connection fee.

Demand assessment is needed to estimate initial demand i.e. proportion of households choosing different levels of service. This assessment will determine the capacity of the system (and therefore the capital cost), but will have little impact on tariffs. In general, designing for a mixed level of service has the following financial implications:

- *subsidy*: current subsidy is set at the capital cost of a basic level of service. If systems are to be designed to allow for a mixed supply, the capital cost will increase. The difference in capital cost between the subsidy and the actual cost needs to be financed, either through tariffs or some other means. Subsidies are a mechanism for wealth redistribution, but need to be used with care in order to signal the economic cost of supply to the consumer;
- *cross-subsidy*: can enable individual connectors (and other users) to subsidise standpipe users, however the price elasticity of demand, and the proportion of individual connectors will dictate the extent to which cross-subsidy is possible;
- *tariffs*: are complex to model. Theoretically, there is a myriad of tariffing options. Practically, it is sensible for standpipe users to pay flat rates and individual connectors a metered rate. In order to satisfy equity and financial objectives, it is recommended that communal standpipe users be charged a tariff linked to the O&M of a basic level of service (also considering affordability), and individual connections be charged the 'average incremental cost' of the O&M, depreciation and capital cost

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(between the subsidy and the actual cost) of supply. Tariffs will also be affected by political, institutional and social issues; and

- *loan finance*: is necessary for micro-financing of individual connections and financing bulk infrastructure. Additional capital expenditure can be financed through tariffs, but loan finance will need to be available to finance the initial negative cash flows.

Facing the reality

Projects currently implemented by DWAF, using a supply-driven approach, are not sustainable. Projects need to respond to effective demand in order to capture WTP. In South Africa, many communities express the desire for a higher level of service, however their WTP is untested. A range of WTP within a community requires the provision of a mixed level of service and systems need to be able to respond to a change in demand over the project life. Supplying a mixed level of service is expensive and effective demand needs to be demonstrated by up-front contributions for yard and house connections.

At one level demand-responsiveness in rural water supply can be realised through greater community participation throughout the project cycle. Technical and financial considerations in designing for a mixed level of service are complex and rely on modelling many assumptions. The extent to which the Water Service Provider — be it a private contractor or community water committee — is consumer-oriented will dictate the financial viability of the project.

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Acronyms and Abbreviations

AADD	Annual average daily demand
BoTT	Build-operate-Train Transfer
CBA	Cost-benefit analysis
CBO	Community-based organisation
CVM	Contingent valuation method
CWSS	Community Water Supply and Sanitation (programme of DWAF)
DCD	Department of Constitutional Development
DRA	Demand-responsive approach
DWAF	Department of Water Affairs and Forestry
FIRR	Financial Internal Rate of Return
IDWSSD	International Drinking Water Supply and Sanitation Decade (1980s)
l/c/d	Litres per capita per day
LOS	Level of service
m³/d	Cubic metres (or kilolitres — kl) per day
NGO	Non-government organisation
NPV	Net Present Value
O&M	Operation and maintenance
p.a.	Per annum
PRA	Participatory Rural Appraisal
RDP	Reconstruction and Development Programme
RWS	Rural water supply
SA	South Africa
UFW	Unaccounted for water
VL0M	Village-level operation and maintenance
Watsan	Water and sanitation
WHO	World Health Organisation
WSA	Water Service Authority
WSP	Water Service Provider
WTP	Willingness to pay

1.

Introduction

‘Effective demand for water means the service that customers demand and are prepared to pay for at a particular price level’.

1.1 Background

Inadequate access to safe water supplies affects millions of South Africans. The problem is particularly severe in rural areas where an estimated 11 million people (65%) do not have access to this basic human need (DCD, 1997). This reality is in stark contrast to a privileged minority who enjoy levels of water provision comparable to any developed nation.

The major cause for this lack of development and inequality is that these areas have been systematically, politically marginalised by the old apartheid regime. Apart from lack of significant investment in rural water supply, many of the water supply systems in existence today have fallen into disrepair and many communities have reverted back to their traditional water sources (Mvula, 1998a).

Development has been given a high priority by the ANC-led government. The primary policy document on development, the Reconstruction and Development Programme (RDP), sees rural water supply (RWS) as a key focus area and has committed substantial funds to the responsible department, the Department of Water Affairs and Forestry (DWAF).

Under the slogan ‘Some, For All, For Ever’, DWAF has undertaken to address the RWS backlog by providing every South African with a ‘basic level of service’ within the next ten years (Ramaema, 1997). DWAF is committed to subsidising the capital cost of supply and expects communities to be responsible for the financing of the recurrent costs of their own supplies (DWAF, 1997a). However, user payment for services is currently very poor — estimated at 1% in 1997 (DWAF, 1997c) — and consequently DWAF spends a significant portion of its budget on supporting these communities (Jackson, 1998a).

The White Paper on water policy (DWAF, 1997a) states that, in future, RWS will be the responsibility of local government. It is proposed that Water Service Authorities and

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Water Service Providers will be the key institutions responsible for project implementation. Few schemes are currently managed by local government and it seems unlikely that these institutions will be able to raise sufficient capital to finance the running costs of supply without user charges.

DWAF has made significant progress over the past few years in bringing water supply projects to many rural areas, however, there is much doubt as to the sustainability of these projects (Mvula, 1998a). It is also doubtful whether it will reach its aim of supplying a basic level of service to the whole country within the next ten years (Jackson, 1998a). The cause of both of these problems is the same: an increasing amount of the budget available to RWS is being spent on financing running costs. Contrary to DWAF policy, communities are not paying for the running costs of supply and this shortage of recurrent income is financed by DWAF.

1.2 Research question

1.2.1 *Problem statement*

RWS projects currently rely on DWAF subsidising the recurrent costs of supply. This subsidy burden is increasing as more infrastructural projects are implemented. There appears to be insufficient funds available for national or local government to be able to continue this role in the future. The subsidy burden is also depleting the funds available for future capital development desperately needed to expand coverage.

Communities are acutely aware of the lack of development in their areas and the inequality in the country. Users are dissatisfied with present levels of service, payment levels of water charges are extremely poor and many systems are riddled with unauthorised connections. It is unlikely that Water Service Providers will have access to sufficient government subsidy to subsidise running costs in the future. Therefore it is imperative that cost recovery through user charges is improved for RWS projects to be sustainable in the future.

DWAF currently subsidise the capital cost of a 'basic level of service' i.e. a communal standpipe supply. Many users aspire to individual connections and are not willing to pay for a supply perceived to be inferior to the house connections enjoyed in affluent urban areas. Other users cannot afford to pay for even this basic level of service.

Payment levels relate to willingness to pay. These vary for different levels of service within most communities. If projects supply only a **fixed** level of service, individuals' willingness to pay is not captured and payment levels will remain poor.

The policy and practice adopted by DWAF at present is resulting in RWS projects being implemented in a supply-driven approach. This is resulting in poor payment for services and consequently a shortage of recurrent income. A demand-responsive approach is needed in order to design for improved financial and service sustainability.

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If recurrent costs are to be financed through users charges, RWS needs to be linked to *effective demand*. This demand is assessed by establishing users' willingness to pay for particular levels of service. A mixed level of service needs to be supplied to meet the varied demands of users and design should cater for projected changes in demand allowing households to upgrade their level of service. Tariffs need to be based on the actual recurrent cost of supply.

1.2.2 Aims

The broad aim of the research is to inform the debate regarding the sustainability of RWS in South Africa. It considers the appropriateness of adopting a demand-driven approach to improve cost recovery through user charges. It argues that an understanding of effective demand is needed in order for projects to be consumer-oriented. The research targets designers and planners and has the following three specific aims:

- (i) to investigate methods (by conducting a literature review) by which projects can respond to demand by:
 - distilling research (predominately within an economic paradigm) into a language that has practical implications for designers and planners;
 - considering the demand-responsive approach;
 - investigating techniques by which demand can be assessed;
- (ii) to investigate (using a case study) the technical and financial implications of designing to meet demand. This includes:
 - water demands;
 - design standards and criteria;
 - designing for a mixed level of service;
 - capital and recurrent costs;
 - options for cost recovery;
 - tariffs and cash flow; and
 - implications for subsidy;
- (iii) to draw conclusions from the case study into recommendations for the South African water sector.

1.2.3 Methodology

The methodology used to investigate these aims is:

- a literature review of international lessons learnt about sustainability, this includes methods of financing RWS and techniques used to assess demand;
- to consider all the factors affecting the sustainability of RWS in South Africa;
- to compare the current supply-driven approach taken by DWAF with a demand-responsive approach;
- a case study applying the design principles to a typical rural village. Different scenarios (with different levels of service) are considered in terms of water demands and costs of supply. Options for cost recovery and financial sustainability are outlined;
- a comparison of the results of the case study with other similar studies.

1.3 Scope of the study

The sustainability of RWS projects is dependant on a number of factors, in particular social, technical, economic, financial, institutional, environmental, political and legal constraints. This study considers two specific issues as being the most pressing in the SA context at present:

- the financing of the recurrent costs of supply; and
- the institutional arrangements needed to enable this.

There is no doubt as to the significance institutional issues have to project sustainability: the roles of the proposed Water Service Authorities and Water Service Providers will be central to the success of future and existing projects. Environmental sustainability (protection of the resource) is also essential to project sustainability. However, this study will address the specific issue of financing the future costs of supply, i.e. operation, maintenance, replacement and upgrading. The study considers methods that can be used to predict initial and future demand and the implications for the designer of designing to meet these demands.

The topic of water supply is usually discussed alongside the provision of sanitation (in particular excreta disposal). There is a very good rationale behind this as any public health benefits from water supply will only really be seen if it is combined with sanitation and health and hygiene education intervention. For simplicity, however, only the issue of water supply is discussed.

The analysis has been done using data from a typical rural village in the Northern Province. Design criteria are consistent with the guidelines as recommended by DWAF (DWAF, 1997b). The water demands cater for domestic and institutional users, but not agricultural, stock or other uses. Costs have been calculated for material, labour, plant and professional expenses (for May 1998) as close to predicted costs as possible. These costs rely on quotations from suppliers, personal communications and the experience of the author. A number of cost recovery options have been considered. Some implications for subsidy, tariffs and project cash flow have been calculated.

A literature review has been conducted on the following topics:

- financing of RWS, in particular: viewing water supply as an economic good, approaches to financing through government and donor agency subsidies and user charges' and principles and techniques that are used to improve cost recovery; and
- demand assessment: a review of the demand-responsive approach and techniques currently used to assess demand.

Much of the economic theory and demand assessment literature focuses on large urban schemes. Financial and institutional arrangements have also sometimes assumed large water utilities. An attempt has been made to adapt and apply some of these principles to small, rural water schemes with local community-based management.

1.4 Structure

The structure of the study follows an approach sometimes used in planning. Chapters are structured by answering the following questions: *Where are we? Where do we want to be? How do we get there?*

1.4.1 *Where are we?*

Chapter 2 outlines the existing situation regarding RWS in SA. It describes the current legislative, policy, institutional and financial environment and water supply coverage levels in order to understand the context of project design and implementation. Factors affecting the sustainability of RWS projects in general are considered and applied to the SA context. The consequence of using a supply-driven approach is argued to be an important factor resulting in poor cost recovery.

1.4.2 *Where do we want to be?*

A literature review is undertaken in **Chapter 3** to investigate the lessons learnt internationally regarding sustainability. Current thinking and research on approaches to the financing of RWS projects is reviewed. The implications of managing water as an economic as well as a social good are considered and how these can affect approaches to RWS financing.

1.4.3 *How do we get there?*

Two specific design issues to enhance project sustainability are considered: demand assessment and designing to meet this demand.

Chapter 4 describes the factors affecting demand and the importance of understanding demand as willingness to pay. It describes the demand-responsive approach as defined by the World Bank and other agencies and its appropriateness to the SA context. Direct and indirect demand assessment techniques are reviewed.

Chapter 5 considers the detailed technical and financial implications for design. It applies the design principles recommended in Chapter 3 to a case study. Tariffs are recommended and cash flow and subsidy implications considered. Comparisons are made with similar studies.

Chapter 6 reviews the findings from the literature review and the analysis of the case study. Recommendations for SA are made, and areas for further research work are identified.

2.

Sustainability

‘Sustainability is the most desirable, yet elusive characteristic of a water supply project’ Adapted from WHO, 1994

2.1 Current situation

South Africa has a substantial economy with a well-developed infrastructure, however significant inequalities exist in both distribution of, and access to the infrastructure. This is particularly true regarding rural water supply.

South Africa has recently undergone major political change. This change has seen widespread political democratisation and has resulted, in particular, in extensive changes to the water sector. The transformation has affected every aspect of the sector from the constitution, policy environment, financial allocations, and institutional responsibility to actual delivery. These changes have tried to restructure and rationalise a previously complex and discriminatory sector.

This report does not investigate any of these changes in detail; but in order to understand the context in which rural water supply is implemented in South Africa at present — and to comment on the sustainability of the approach taken by government and other agencies — the following topics are briefly considered:

- water law;
- policy;
- financial allocations;
- institutional arrangements; and
- rural water supply coverage levels.

2.1.1 Water law

Law has an important, but often poorly understood function in the implementation of water policy (Howsam, 1998). The old South African legal standing on water use was based on two important ideas (DWAF, 1997a):

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- a) the riparian principle: a link between the right to use water and the ownership of land adjacent to that water; and
- b) a separation between private and public water.

This resulted in water rights being integrally linked to land tenure, and few legal rights for (particularly marginalised) communities to an adequate water supply. This (resultant) discriminatory legislation has undergone major review and the new principles governing water have been recently accepted by parliament (on the 18th August 1998) in the National Water Bill (DWAF, 1998a).

The Bill of Rights in the new constitution of South Africa states (DWAF, 1997a):

‘Everyone has the right to have access to sufficient water’.

In addition, it confers on all citizens a right:

‘to have the environment protected for the benefit of present and future generations’.

It is with these two constitutional rights in mind that the new SA water law has been developed. DWAF has used a consultative process to establish 28 fundamental principles (DWAF, 1996). These principles relate to: the legal aspects of water, the water cycle, water resource management priorities and approaches, water institutions and water services.

The major departure from the old water law is that all water (surface and ground water) is now regarded as a national resource to be owned and managed by the state. This has major implications for the environment, water use allocation and water management. Water required to meet peoples’ ‘basic human needs and the needs of the environment’ is identified as ‘the Reserve’ in the principles (DWAF, 1997a, Principle 8 and 10). This should enjoy ‘priority use’ and all other uses will be subject to authorisation. A ‘Natural Resource Court’ has been proposed to implement the new water law.

The principles are in line with current ‘progressive’ thinking concerning water law (Howsam, 1998) and acknowledge the necessity for water to be managed in a sustainable manner.

2.1.2 Policy

DWAF has taken the lead with respect to national policy development for water provision. The White Paper on National Water Policy (DWAF, 1997a) highlights the following key policy principles:

- development should be demand-driven and community-based;
- basic services are a human right (however they do not imply the right of an individual person or community to demand services at the expense of others);

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- equitable regional allocation;
- water has economic value;
- the user pays;
- integrated development; and
- environmental integrity.

These principles reflect the goal, captured in the new slogan: ‘Some, For All, For Ever’ (adapted from ‘some for all rather than more for some’ — statement adopted at the conference in New Delhi to review the achievements of the International Drinking Water Supply and Sanitation Decade — King, 1993). This sums up the goals of:

Some — access to a limited resource;

For All — expanding coverage on an equitable basis;

For Ever — in a sustainable manner, now and in the future.

The RDP outlines short, medium and long-term aims for water supply (ANC, 1994 p29). The White Paper expands on these aims by setting as the short-term aim: to ensure that all South Africans have access to a ‘basic level of service’ (DWAF, 1997a). This is defined as 25 litres per capita per day (l/c/d) to within 200m maximum cartage from any household. Other criteria such as: availability, assurance of supply and quality are also defined.

The policy principles outlined in the White Paper conform to current international good practice (PDG, 1998), however even the most brilliant piece of policy-making will fail if implemented badly (Carter and Howsam, 1998). It is questionable whether the principles have been applied in practice to the Community Water Supply and Sanitation (CWSS) programme of DWAF (PDG, 1998). Two of the principles in particular, ‘development should be demand driven’ and ‘the user pays’, are fine ideals — and investigated in depth in this report — but are not practised on current projects (Mvula, 1998a).

2.1.3 Institutions

In the past, no single agency was responsible for RWS in the country (Tainton, 1997). There was considerable overlap of responsibility within the water sector between central government departments, former ‘homeland’¹ governments, parastatals and water boards. The White Paper (DWAF, 1997a) proposes that the responsibility for RWS in the future falls on two distinct tiers of government:

¹ Homeland refers to the former ‘independent states’ as empowered and recognised by the former apartheid regime

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- *National government* (through DWAF): is to play a more facilitative role through creating the enabling policy environment, legislation and financial allocations. Water resource management will also fall under national government; and
- *Local government*: will be responsible for the direct provision of services i.e. water supply. The development of local government is currently supported by the Department of Constitutional Development (DCD). The future of the CWSS Programme run by DWAF is unclear.

The process of implementing this new institutional arrangement is currently under transition. In practice, regional government is a key institution in facilitating the transition, and institutions involved in RWS differ across the nine provinces. Figure 2.1 tries to unpack some of the complex institutional responsibilities and activities (based on DWAF, 1996, 1997a and 1998a). Activity and responsibility matrices are usually used for institutional appraisal, and conducted by staff in order to clarify (and rationalise) management functions. This matrix does not attempt to capture all stakeholders and functions in the sector, or even accurately describe their responsibility, involvement or interest; it is an interpretation of the current situation shown to orient the reader to the complexities of the rural water sector in SA. The situation is transitional and different in other provinces, however this matrix tries to show a ‘snap shot’ of current institutional arrangements in the Northern Province. Proposed institutions are shown in parenthesis.

Figure 2.1. Indicative activity/responsibility matrix for the South African rural water sector (in a Transitional Policy Environment).

Responsibility	Activity																		
	Legislation & dispute resolution	Policy development & implementation	Sector Strategic Planning	Subsidy decisions • capital • recurrent	Financial Allocation	Budgets	Water Resource Allocation	Project Identification	Project Planning & Design	Project Implementation	Water Quality	Management of Community Involvement	Tariff setting	Management of O&M	HRD	Training of community CBOs	Monitoring & Evaluation	Research	
National Government																			
Parliament																			
DWAF																			
DCD (MIP, EMIP & CMIP)																			
Other financiers ¹																			
(National public water utility)**																			
(Natural Resources Court)																			
Water Research Commission																			
Provincial Government																			
DWAF ²																			
Local Government																			
District Councils																			
TRCs ³																			
Private Sector																			
Water Boards																			
Consulting Engineers																			
Contractors																			
BoT contractors																			
Training institutions																			
NGOs ⁴																			
CBOs ⁵																			
Project Steering Committees																			
(Statutory Water Committees)																			
Community Water Committees																			
Consumers																			

** Proposed institutions in parenthesis

¹ e.g. DBSA, IDT, international funders

² Catchment Management Agencies

³ Transitional Rural Councils

⁴ Non-Government Organizations

⁵ Community-based Organizations

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Comments on the matrix:

- Three new institutions are proposed in the White Paper: a National Public Water Utility, a Natural Resource Court and a Catchment Management Agency.
- Responsibility for many activities overlap — this is due to transitional arrangements and lack of co-ordination.
- DWAF have dedicated significant amounts of their present budget to BoTT (Build-operate-Train Transfer) projects. Apart from other concerns, it is the author's opinion that the sustainability of these projects hinge on the training and capacity building given by the BoTT contractors to local governments to operate the systems in the future.
- Consulting engineering firms have historically dominated the water supply sector (in planning and implementation) particularly in the old 'homeland' administrations. They presently play the major part in shaping provincial and local government decisions and are the principle agents for implementation.
- The future role of water boards in rural areas is not clear.
- Community participation in DWAF projects has been in the form of Project Steering Committees and Water Committees; however many projects have been implemented without real involvement of these committees. This is largely due to insufficient and inadequate training of these groups and no real political will to elevate their position. Community involvement is generally not early enough in the project cycle and often does not allow communities to make any real input into the design and construction stages. The community is often saddled with the complex task of operation and maintenance with an inappropriately designed system that does not adequately serve their needs. Very little thought is given to cost recovery on the systems and DWAF have 'baled communities out' of dysfunctional projects, rather than spent the resources on training.

Significant confusion and uncertainty has arisen about the future role of local government in service provision (Mvula, 1998a). In order try to clarify and rationalise responsibilities in this key area of RWS, the following institutional distinction has been made (PDG, 1998):

- Water Service Authority: this will be local government (most likely through District Councils); and
- Water Service Providers (WSP): here, a range of possible institutions have been considered: Transitional Local Councils (TLC), private sector, BoTT contractors and statutory water committees (local community-based water committees with statutory recognition).

This framework has been accepted in the Water Services Act (1997), but has not yet been implemented (PDG, 1998). Further recommendations on institutional arrangements can be found in the CWSS Evaluation (Mvula, 1998a) and the Green Paper for Local

Government. In this study, for simplicity, the WSP will be regarded as the principle agent concerned with all RWS issues.

2.1.4 Finance

Financial allocations to RWS are ultimately decided by the Department of Finance through the national budget (Jackson, 1998a). Table 2.1 shows the proportion of the national fiscus currently allocated to RWS.

Table 2.1. The South African economy

Population	38 million
Rural Population	17 million (45%)
Gross domestic product, 1997	R 675 billion (US\$ 135 billion)
Average government contribution to RWS, past 3 years	R 705 million per year (US\$ 141 million)
RWS spending as share of GDP	0.1%

Source: Palmer, 1998

Funding and subsidy policy for RWS has been shaped by the two national government departments primarily responsible: DWAF and DCD. The initial thinking regarding subsidy policy was spearheaded by DWAF, but as responsibility for RWS shifts from DWAF to local government, DCD plays a more significant role.

2.1.4.1 Department of Water Affairs and Forestry

The White Paper states that services should be self-financing at a local and regional level. Where poor communities cannot afford basic services, government may subsidise the capital cost of a 'basic level of supply'; but not the operating, maintenance and replacement costs (PDG, 1995). This implies a capital grant available for RWS for marginalised communities, however, many of the detailed policy implications are still under review. A recent evaluation of the CWSS programme of DWAF made the following policy recommendations regarding financial arrangements (Mvula, 1998a):

- grant finance rules need to be established to ensure equitable distribution of resources. PDG (1998a) suggest that a capital subsidy ceiling be set at R250/capita for bulk infrastructure and also R250/cap. for distribution infrastructure;
- the option of up-front financial contributions needs to be considered as a basis for strengthening sustainability;
- loan finance instruments need to be developed to support mixed service level arrangements; and
- budget control systems need to be strengthened.

2.1.4.2 *Department of Constitutional Development*

Investment under the DCD has evolved through the following three programmes: the Municipal Infrastructure Programme, Extension of the Municipal Infrastructure Programme and the more recent Consolidated Municipal Infrastructure Programme (CMIP). The aim of CMIP (as inherited from DWAF) is to ensure that all communities have access to at least a basic level of service within 10 years from the start of the programme (1994) (PDG, 1998). RWS has received an average of 9% of the total budget allocated to the CMIP programme to date, this is expected rise to between 10 and 20% over the life of the programme.

Grants from CMIP are DCD allocations to local governments for the provision of services. PDG (1998) give a break down of current expenditure from the CWSS programme of DWAF, the various DCD programmes and future grant requirements. Significant to this report, is the proposal (and likely acceptance — PDG, 1998) of a rationalised rural infrastructure subsidy to be allocated by DCD for:

- *grant financing of capital costs* — of which water supply will be a portion (estimated at about 23%) along with sanitation, electricity, roads and stormwater; and
- *running cost subsidy* — based on the new ‘equitable share’ allocation (anticipated allocation to rural local government of a portion of nationally raised revenue). Calculations done by PDG (1998) estimate this amount to be around R56/household/month (based on 53% of rural households earning less than R800/month and average rural household of 5.6 people) intended for the payment of services.

2.1.4.3 *Other financiers of RWS*

A1.1.1 *Mvula Trust*

The Mvula Trust is a local independent NGO, which has funded RWS in SA over the past five years. It runs a water programme in parallel with DWAF aimed at rural and peri-urban communities below 5,000 people. It has had significant influence on the policy and practice of DWAF (Palmer, 1998). It operates on a fixed limit, capital grant subsidy with up-front contributions required from the beneficiary community towards O&M.

A1.1.2 *Development Bank of South Africa*

The DBSA fund some RWS projects. It is presently considering loans to WSP for increasing capacity over the basic level of service and other financing options (Jackson, 1998a).

A1.1.3 *Others*

NGO's and local and international donor agencies have made significant contributions to RWS in the past. Their role in the future is outside the scope of this research.

2.1.5 Coverage levels

Water is essential to life, and therefore all people rely on (and have) some form of water source. However, in many cases, this source yields unclean or insufficient water or may be many hours walk from the people who use it. This inadequate access to safe drinking water (there are many definitions of 'adequate' access, and 'safe' water — the SA definition is taken as the RDP 'basic level of service') results in suffering due to poor public health and energy spent on collecting water. Globally, 2.9 billion people lack adequate sanitation and 1.2 billion are without access to safe water (WELL, 1998). Global water coverage has improved since the International Drinking Water Supply and Sanitation Decade (WHO, 1996). Table 2.2 illustrates the percentage of people with an adequate water supply globally and in Africa in 1990 and 1994.

Table 2.2. Global and African water coverage (1990–94)

	1990		1994	
	Population (millions)	% coverage	Population (millions)	% coverage
Global				
Urban	1,389	82	1,594	82
Rural	2,682	50	2,789	70
Total	4,071	61	4,383	75
Africa				
Urban	201	67	239	64
Rural	432	35	468	37
Total	633	45	707	46

Source: WHO, 1996

Globally, RWS coverage levels are quoted as having dramatically increased between these years. This increase is primarily due to the statistics quoted for Asia and the Pacific (2,097 million rural people — 78% of the world's rural population — coverage levels increasing from 53 to 78%). These figures seem unrealistic, but may be due to inaccurate and inconsistent procedures for collecting coverage data. African levels have stayed much the same.

Current coverage levels in South Africa are not accurately known (PDG, 1998). Many estimates have been made by a number of different agencies in SA, but much of the data are conflicting. The rural population, based on the provisional results of the 1996 national census was estimated at 16.9 million, representing 45% of the total population (CSS, 1997).

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PDG (1995) have tried to make sense of the conflicting data by comparing the findings from five different authoritative sources. The data were synthesised to produce the following table using the levels of service as defined:

Table 2.3. Rural water coverage in SA

<i>Level of service</i>	<i>Description</i>	<i>% coverage</i>
Minimal	No infrastructure in place	40
Upgradable	Upgrading required in order to be classified as basic	25
Basic	25 l/c/d to within 200m of every resident	20
Intermediate	Households have access to yard taps	10
High	Households have access to in-house connections	5

Source: PDG, 1995

These figures suggest that 35% of rural dwellers have access to an ‘adequate’ water supply i.e. 65% do not. This correlates to a population of 11 million, using the provisional 1996 census figures — this figure has been used by the Municipal Infrastructure Investment Framework (DCD, 1997). It is interesting to note that although SA is regarded by many as a relatively wealthy and developed country in Africa, RWS coverage in SA is about the same as the African average.

2.1.5.1 RWS projects

A1.1.1 DWAF

Under the CWSS programme, DWAF has allocated funding to 1,025 projects, which will serve 4.8 million people. It has been estimated that since 1994 1.2 million people have received new water supplies from this programme (PDG, 1998). At the present rate of delivery i.e. that achieved in the first three years of the RDP, it will take 30 to 40 years to supply everyone in the country with a basic level of service. DWAF have found this time frame politically and morally unacceptable (Ramaema, 1997) and have set two major objectives:

- address backlog of water supplies (serving 11 million people) within a ten year period; and
- expending R 1,000 million p.a. on projects to achieve actual delivery.

The 1998 DWAF budget has recently been drastically cut — from R1,200 million to R432 million (press release: DWAF, 1998b). It is not clear whether these funds are lost to RWS, or whether a significant portion will now be administered by DCD.

A1.1.2 Mvula Trust

Between 1993 and 1995 the Mvula Trust have implemented projects estimated to serve 400,000 people (Palmer, 1998).

2.2 Sustainability of projects

2.2.1 *What is sustainability?*

Ever since world leaders adopted Agenda 21 at the Earth Summit in Rio de Janeiro in 1992, sustainability has been central to the development debate. In the global sense, sustainability is considered primarily in terms of ‘continuing to improve human well-being, whilst not undermining the natural resource base on which future generations will have to depend’ (Abrams, 1998). In terms of this report, sustainability refers to the satisfactory operating of RWS projects over their planned life (based on WELL, 1998).

Although sustainability has been given such a high priority over the past few years, little is known about how to achieve it. Vast quantities of money are spent every year around the world on rehabilitating water projects that have fallen into disrepair (Abrams, 1998). The term ‘sustainability’ is used by policy-makers and politicians throughout the world, but there is little evidence of this illusive aim being achieved.

At one level, the sustainability of a RWS project is easy to define: if the system works as it was designed over the project life i.e. if someone returns to a village 20 years after a project has been implemented and turns on a tap, and water flows at the rate and of the quality intended, the project could be termed sustainable. However, for this to have happened, there are a host of factors which, in some manner, must have been in place.

2.2.2 *Existing projects*

2.2.2.1 *DWAF*

Sustainability is a key principle in the policy of DWAF. ‘Some, For All, For Ever’ places a high priority on sustainable development, however, existing projects seem far from this aim. A recent evaluation of the CWSS programme of DWAF (Mvula, 1998a) concluded that:

‘While there has been admirable progress in implementing projects, there are some serious concerns about the sustainability of these projects’.

The most important reasons cited are:

- insufficient emphasis on training and participative planning;
- insufficient attention given to organisational development and financial viability of service providers;
- projects are often unnecessarily expensive, with the risk that people will not be able to afford the services provided; and
- the potential social spin-offs (health, empowerment of women etc.) have not been maximised.

A workshop was held with DWAF staff and others to review the evaluation (Mvula, 1998b). Eight recommendations were made by the participants in order to try to improve sustainability. All of these issues (in some form) are captured within Figure 2.2, but the

most pertinent to this report recommends designing for cost recovery and customer requirements. It mentions that emphasis needs to be placed on a mixed level of service approach.

In another recently prepared status report on the operation and maintenance aspects of the CWSS programme (DWAF, 1997c), the problem seems even more serious. This report deals with new and old DWAF projects and concludes (some of the listed conclusions in PDG, 1998):

- there is almost total lack of cost recovery due to negligible payment for services (cost recovery is estimated at around 1% across the country — DWAF, 1997c);
- a proliferation of unauthorised connections; and
- poor maintenance.

2.2.2.2 Mvula Trust

PDG (1998) in personal communications with Mvula Trust staff estimate that of the 126 RWS projects completed to date, 70% can be considered successful i.e. sustainable. The main reason attributed to the failure of the balance is due to a breakdown of community management structures. Chibi et al (1997) in an evaluation of two Mvula projects in Mpumalanga conclude that payment for water is not being successful, mainly due to lack of efficient tariffing and collection systems.

In general it is accepted that Mvula projects are significantly more sustainable than DWAF projects. This is due to a number of reasons, some as listed in Palmer (1998):

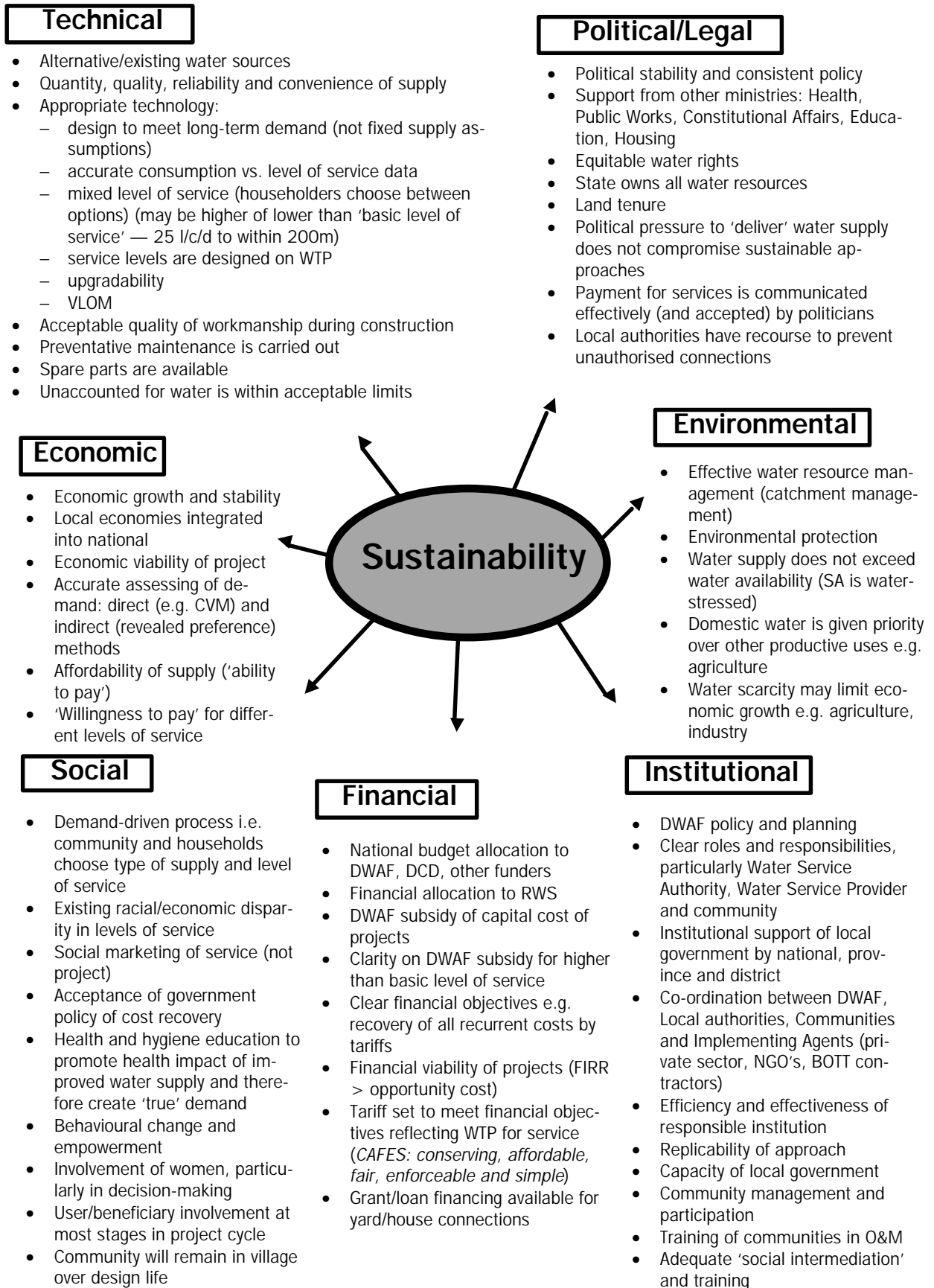
- a demand-driven approach is used;
- all projects are managed by community structures;
- financial control is completely through community structures; and
- a strong emphasis on social intermediation and training.

2.2.3 Factors affecting sustainability

Figure 2.2 is an attempt at summarising the factors affecting sustainability of RWS projects in SA. It has been developed by the author and incorporates ideas from many sources (World Bank, 1998; Abrams, 1998; Jackson, 1998a; Vienings, 1998; White, 1997 and personal communications). The diagram incorporates experience from other countries as well as SA. WELL (1998) propose that sustainability has environmental, institutional, financial, technical and social dimensions, the author has added three more dimensions to this analysis viz. political, legal and economic. Many of the factors listed in the ‘spider diagram’ will be detailed later in the report.

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Figure 2.2. Factors affecting sustainability



2.3 Problem statement

2.3.1 Supply-driven approach

Figure 2.2 illustrated the many factors affecting sustainability. Projects currently implemented by DWAF seem not to be sustainable. It is the author's opinion that a major reason for this is that projects are 'supply-driven'. Asthana (1997) comments that the 'some for all, rather than more for some' policy called for at the New Delhi conference can easily result in a 'minimum unsatisfactory virtually free service to all' approach. He suggests that we should rather strive for 'improved service to all and higher level of service to those who are willing to pay for more'.

The White Paper (DWAF, 1997a) outlines a number of policy principles aimed at creating an environment in which projects respond to actual demand (demand-responsive approach), however, in practice, many commentators agree that most projects implemented by DWAF to date have taken a supply-driven approach (e.g. Jackson, 1998a; PDG, 1998). This means that projects still focus on supplying a service based on assumptions regarding need. Projects are designed to supply the minimum basic LOS as defined in the RDP and do not necessarily respond to actual (real or effective) demand. In some areas, this is too high and too expensive a standard, while in others it is rejected as too low a standard (PDG, 1998b; Mvula, 1998a). Not surprisingly, most potential consumers want the highest LOS possible. They will assure project sponsors that they are willing to pay the running cost involved, however experience is showing us that this is not happening (Jackson, 1998a). The primary reason for this is that tariffs are not matched to individuals' willingness to pay for particular LOS, and in turn these tariffs are not necessarily related to actual costs.

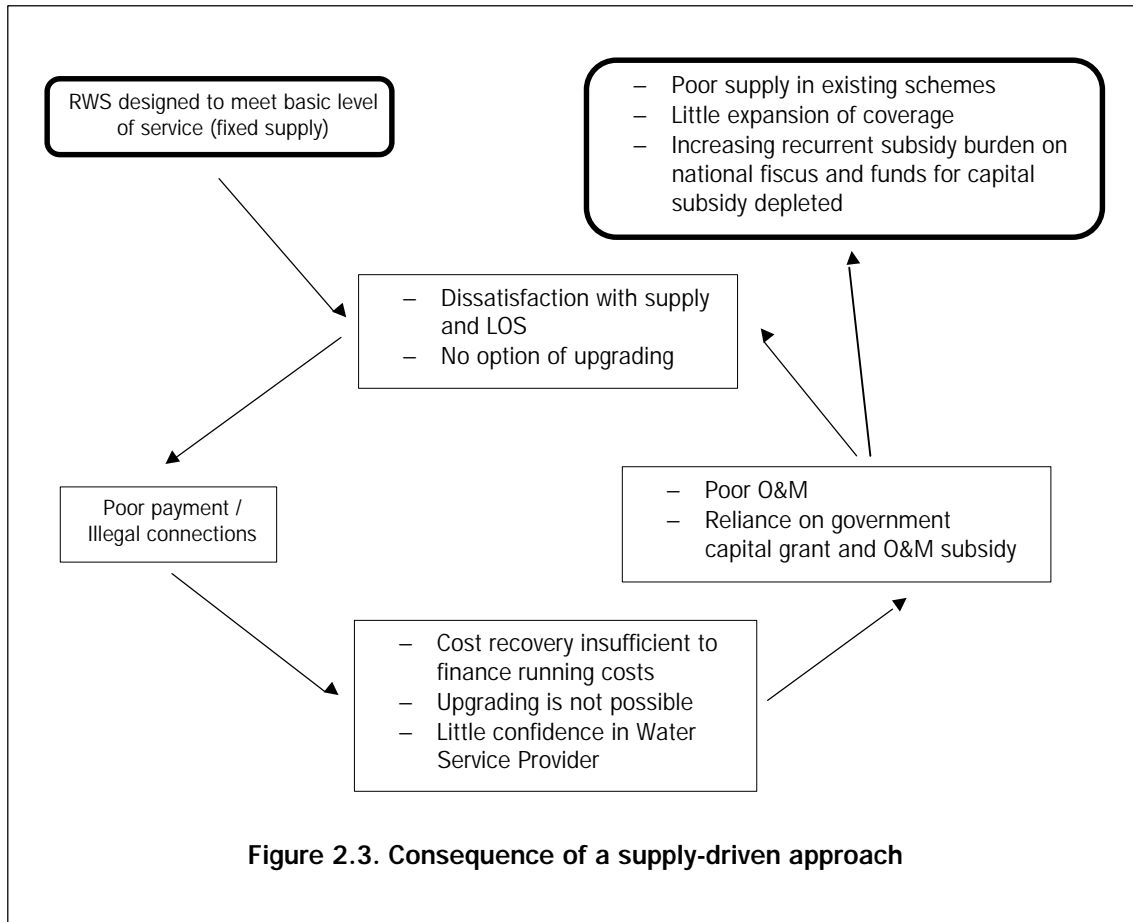
Key problems of a supply-driven approach within the perspectives used for sustainability are:

- *Technical*: design is based on the assumption that all residents will be willing to pay for a new supply at a fixed level of service;
- *Economic*: water supply is seen as having purely social value (as opposed to economic) and as a responsibility of government;
- *Financial*: water is usually underpriced (World Bank, 1998);
- *Institutional*: a centralised 'top down' approach is used; responsibilities are unclear; and
- *Environmental*: resources are not allocated on an economic basis. This results in potential wastage of the resource, as there is no incentive for conservation.

This last factor should be taken very seriously when considering that globally, the rate of increase of water use is more than twice the rate of population growth during this century (quoted by the UN Secretary-General in the 1997 'Comprehensive Assessment of the Freshwater Resources of the World' — WELL, 1998). SA is classified as a water

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stressed country, predicted to reach absolute scarcity by 2025 — Ohlsson, 1995. Figure 2.3 illustrates some of the possible consequence of using a supply-driven approach.



2.3.2 Narrowing the focus

Many factors were listed in Figure 2.2 as affecting sustainability. The author believes that the most pressing in the SA context at present are financial and institutional, but this study tries to address the specific problem of financing the recurrent cost of supply. The current supply-driven approach is unsustainable for two main reasons:

- the cost of financing the running costs of present systems (estimated at R1 billion p.a. — Jackson, 1998a) and continued capital investment, albeit for a basic level of service, is far in excess of national budgets dedicated to RWS. Current coverage levels of DWAF are not even keeping up with the rate of population growth (Vienings, 1998); and

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- unpaid for water leads to wasteful use of water (e.g. WHO, 1994; WELL, 1998). An appreciation of the economic value of water is essential to reduce waste and loss, encourage conservation, and move consumption towards higher value users. Beneficiaries need to be sent the message of the economic cost of supply by linking tariffs to actual costs.

3.

Financing Rural Water Supply

'Water is free at the source; service provision costs money — this needs to be financed' Adapted from WHO, 1994

Chapter 2 argues that the key problem of the sustainability of RWS projects in SA is the financing of the recurrent costs of supply due to a supply-driven approach. This report is oriented towards planners and designers and assumes a technical orientation. In order to understand the issues surrounding demand assessment and the consequences for design, a broad understanding of some financial and economic principles is needed. The economics of water supply is a broad subject and could be the topic of many projects, however, it is important for the designer to understand certain principles in order to appreciate the economic paradigm in which water supply can be viewed.

3.1 Water as an economic good

3.1.1 *Economic good vs. social good*

In the past, water has been viewed primarily as a social good. As described earlier, the constitution of South Africa views an adequate water supply as a basic human need that every citizen has a right to access. The supply of water, like other basic needs, was seen as the sole responsibility of government, primarily to protect public health. Central government has committed substantial amounts of money towards constructing water supply schemes and despite policies to the contrary, continues to finance the running costs of most of these systems (Mvula, 1998a). Governments have always been prepared to subsidise water supply because of this social good.

Water can also be viewed as an economic good, because it has value. The test used by economists to illustrate this value is that some users are willing to pay the economic cost of providing the service (Garn, 1998). This willingness to pay shows the extent to which users value the benefits gained from supply. In the past, it was usually believed that the true (economic) cost of supply was unaffordable to beneficiaries, and few real attempts have been made at recovering any of these costs from user charges (Garn, 1998). Today, however, largely due to funding shortfalls, many governments are requiring users to pay some of the costs of supply and this requires water supply to be viewed in economic terms.

These conflicting perspectives of water as a social and an economic good have been hotly debated for decades and this debate will perceptibly continue over the next decades. The externalities² associated with water supply are used as an argument for state subsidy and this raises the question of how much the private citizen should pay.

Another aspect of considering water as an economic good, is the relative value water has for different uses e.g. domestic and agricultural (Smout, 1998). Irrigated agriculture is by far the biggest consumer of water, but also a substantial waster of water (irrigated agriculture in SA should be able to achieve the same levels of production using 25% less water — Ohlsson, 1995). This has implications for subsidy and water allocations between the sectors.

In order to reach global coverage figures as planned in Water 2000 (extension of IDWSSD), Cairncross and Kinnear (1988) lists four possible ways to improve coverage:

- (i) reduce unit costs;
- (ii) increase investment from external sources;
- (iii) increase investment from national governments; and
- (iv) increase cost recovery from users.

The use of appropriate technology is one attempt at cost containment (the use of community participation is another important method). These should always be considered in design, however, there are limits to the reductions in cost that can be achieved without compromising reliability (Cairncross and Kinnear, 1988). There is little likelihood of increased investment from foreign investors in South Africa in the future — with the advent of a ‘legitimate’ political dispensation, many foreign donors that justified investment in SA in the past on political grounds may not be as forthcoming in the future (Abrams, 1998). Likewise, the money available within SA for RWS seems, if anything, to be decreasing (DWAF, 1998b).

It is this last method that has received most attention over the past decades. Increasingly, it is being realised that in order to charge prices related to the economic cost of production, water needs to be sold as a commodity. This is essentially viewing the supply of water as a ‘market’. For markets to operate efficiently, supply needs to match demand, and, in that way, projects need to be demand-responsive, as opposed to supply-oriented.

If communities are responsible for financing the recurrent costs of supply, Water Service Providers need to ‘sell’ water as a commodity. This requires social marketing of water services and a general consumer-orientation (Kayaga, 1997). Most importantly, consumer demands need to be understood, and supply needs to be tailored to meet these demands. Consumers need to be able to choose the level of service for which they are

² Externalities are effects of a project felt outside the actual project itself, and not included in the valuation of the project. Such effects commonly include damage to the environment or public health (DFID, 1999)

willing to pay and WSPs need to meet these varying demands to be financially sustainable.

This perspective of water supply as a market has serious implications for policy. For systems to be financially sustainable the level of service provided needs to be financed through user charges. It therefore does not make economic sense to fix a level of service that government will subsidise — effective demand may be higher or lower than this basic level of service.

3.1.2 Objectives of an improved water supply

In order for policy to be effective, the objectives of an improved supply need to be clearly defined. Different stakeholders may arguably have different objectives:

- a) *beneficiaries*: Convenience appears consistently to be the most significant reason for beneficiaries wanting an improved water supply (WHO, 1994), however many others exist e.g. status, irrigation etc. The experience of industrialised countries — where consumers are willing and able to pay for very high levels of service — can result in the provision of the highest level of service to be an objective in itself (Cairncross and Kinnear, 1988). In SA, the major disparity in LOS across the country is possibly the main reason consumers felt needs are for a high LOS. Satisfying these objectives can result in inappropriately expensive systems being constructed which are unable to be financed through user charges;
- b) *politicians*: In most low-income countries, there is strong public demand for improved water supplies, so that for politicians, the promise to provide them may be an effective vote-catcher. Governments may have the objective of fulfilling their public obligation and responsibility. Foreign donor agencies may see the potential for improved health that water supply can hold as being their primary objective; and
- c) *economists*: attempt to quantify the benefits arising from an improved supply in economic terms. WELL (1998) list the following as the possible main benefits accruing to beneficiaries from improved water supply:
 - health benefits: from improved quantity and quality of water;
 - time savings: less queuing and collecting time;
 - financial savings: households may need to spend less on water supply e.g. if purchased from water vendors;
 - convenience: reliability and accessibility; and
 - consumer surplus: arising out of increased consumption at cheaper rates.

3.1.3 Economics of water supply

Two topics have been chosen to explore in this section:

- a) the demand curve for water; and
- b) economic analysis.

3.1.3.1 Demand curve for water

The argument for viewing water supply as a market is implicit in treating water as an economic good. For any commodity, market forces of supply and demand will determine price. Economists illustrate this relationship between price and quantity with the demand curve. The demand curve can also be termed the marginal willingness to pay curve (by definition) or the marginal benefit curve i.e. the maximum benefit the consumer will derive for each successive unit as expressed by the maximum the consumer will pay for it.

Demand curves are often approximated by a linear function with a negative slope i.e. an increase in price will result in a decrease in consumption and visa versa. The reason for the negative slope is attributed mainly to (Barker, 1997b):

- the *income effect*: a change in the price of a good will change the available disposable income for all goods (Pearce, 1981); and
- the *substitution effect*: where consumption drops due to an increase in price as one commodity is substituted for another.

Merrett (1997) proposes that a more realistic demand curve for water would take the form of a cubic function (due to empirical evidence of the price elasticity of demand). Many researchers have proposed different methods for estimating demand curves (e.g. Whittington and Choe, 1992; Lovei, 1992), but commonly agree as to the complexity of this task. It is often inappropriate (due to the complexity, and debatable usefulness of the exercise) to estimate demand curves, but some attempts have been made.

In the simplest case, a demand function for water could be expressed as the following (Whittington and Choe, 1992):

$$Q_w = f(P_w, P_o, Y, SE) \quad \Rightarrow \text{equation 3.1}$$

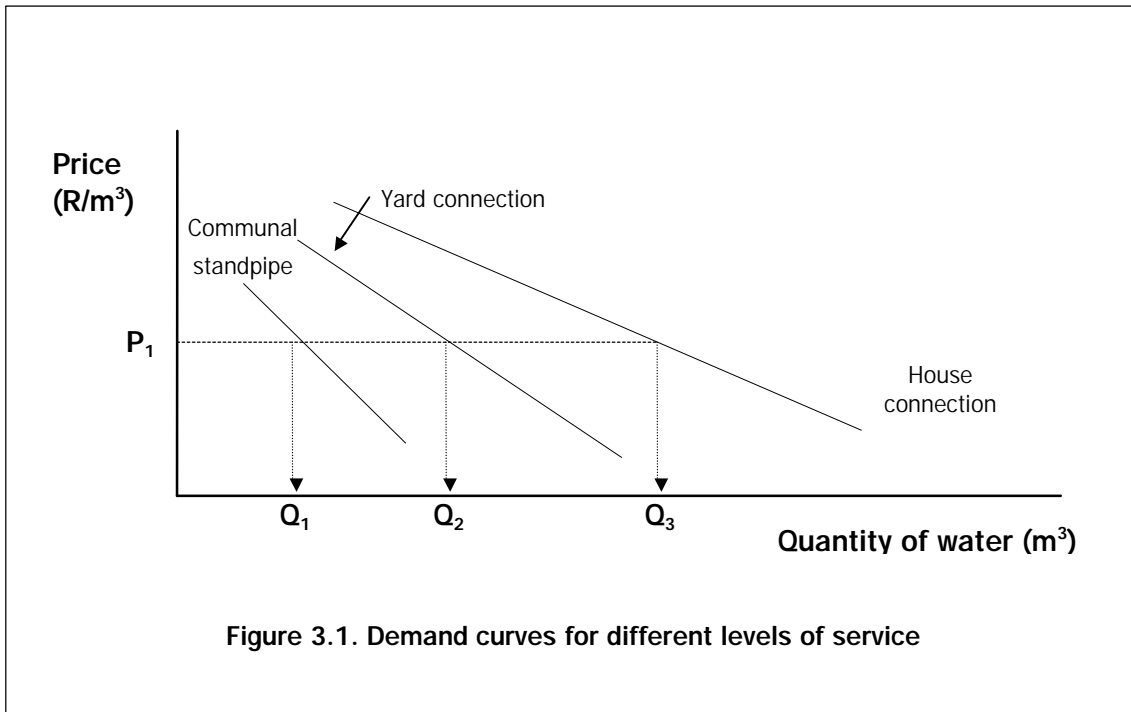
where: Q_w = quantity of water demanded;
 P_w = price of water (or shadow price ³);
 P_o = price of other related goods and services (substitution effect);
 Y = household income (income effect); and
 SE = other socio-economic factors.

These variables determining demand are sometimes termed the ‘determinants of demand’ — these are discussed in more detail in Section 4.1.3. Many researchers agree that different types of supply and different levels of service will display different functions on a demand curve (Waughray, 1998). Consumption will increase for higher levels of service and willingness to pay for higher levels of service is generally assumed to be higher (WELL, 1998). Possible slopes of these demand curves are shown in Figure 3.1 (these curves are drawn from hypothetical scenarios, not from empirical evidence).

³ A shadow price is an imputed valuation of a commodity which has no market price (Pearce, 1981)

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Consider price P_1 charged by the WSP; at this price, communal standpipe uses will consume Q_1 , yard connections Q_2 and house connections Q_3 .



Elasticity of demand

Determinants of demand influence what economists term the 'elasticity of demand' i.e. the impact a variable will have on demand. Caincross and Kinnear (1988) proposes the following major factors influence demand elasticity (these are similar to Equation 3.1):

- price (tariff);
- income (and affordability of supply);
- metering (as opposed to flat rate charging); and
- others (e.g. distance from source, LOS, perception about service provider etc.).

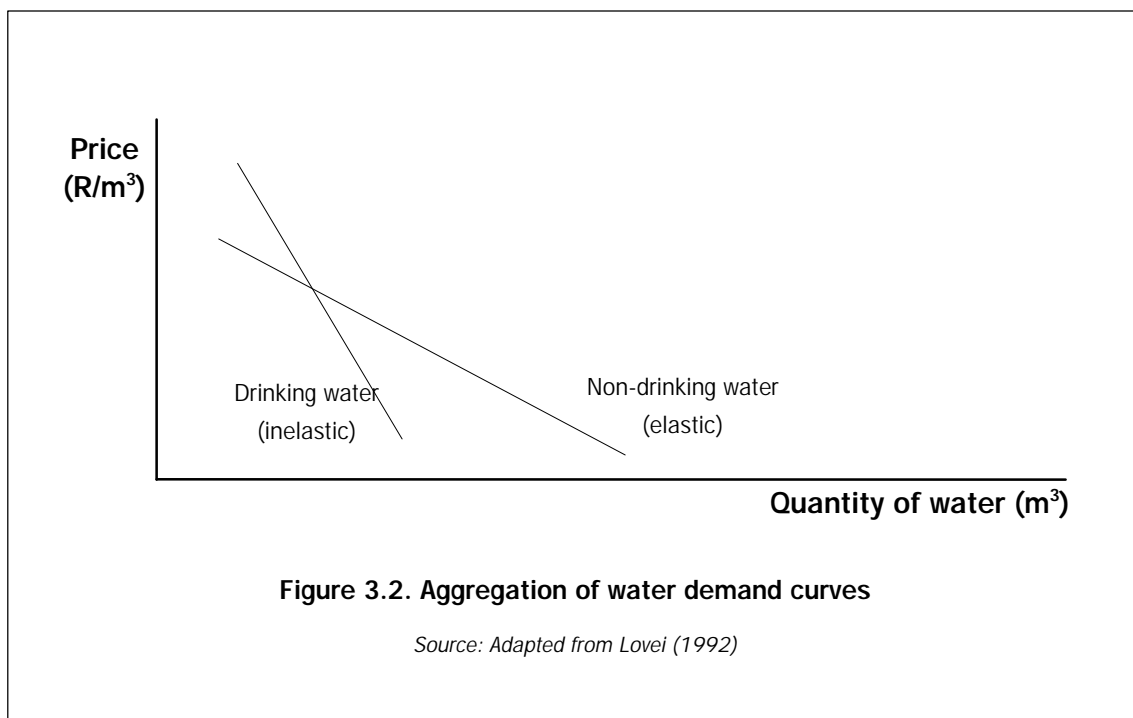
The most commonly calculated factor is price. The responsiveness of consumers change in demand to a change in price is termed the *price elasticity of demand* (E_d). Mathematically this can be represented by the equation:

$$E_d = \frac{\% \text{ change in demand}}{\% \text{ change in price}}$$

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When a change in price exerts a relatively small change in demand it is said to be price inelastic ($0 > E_d > -1$), when change in price significantly changes demand, it is said to be price elastic ($E_d < -1$). $E_d = -1$ is termed unit price elasticity. Price elasticity is often expressed by a percentage e.g. $E_d = 6\%$ implies that a 10% change in price will result in 6% change in demand i.e. the price is inelastic at this point in the demand curve.

The demand for drinking water (and other ‘basic needs’ water) is generally considered to be price inelastic (e.g. Cairncross and Kinnear, 1988; Barker, 1998), whereas the demand for non-drinking water has often been found to be price elastic (e.g. Lovei, 1992). Figure 3.2 illustrates these different hypothetical demand curves and an aggregated demand curve for piped water.



Note the different elasticities of demand in Figure 3.1. This phenomenon can have serious implications for a WSP and regulators, as:

- a ‘revenue maximiser’ will tend to raise tariffs where demand is inelastic, as an increase in price of an inelastic commodity will result in an increase in total revenue (as revenue = price x quantity; also remember profit = revenue - cost); and
- ‘basic needs’ water is price inelastic; therefore, lesser consumers will pay relatively high prices for water, unless exempted or a non-profit maximiser price is charged.

Price elasticity also has implications for cross-subsidy issues. If the WSP tries to subsidise the tariff of the lesser consumers by charging the higher consumers more (for equity reasons), the consumption of the higher consumers may decrease (due to the elasticity of demand of non-drinking water) — this will result in less total revenue.

In other words, price elasticity of demand illustrates a potential conflict of interest for a WSP: revenue generation and equity issues. Theoretically, in order to increase revenue, the price of ‘inelastic’ water should be raised, but for equity reasons, the price of this ‘inelastic’ water needs to be affordable to the poor. Practically, it may not be sensible to differentiate between ‘inelastic’ and ‘elastic’ water.

Cross-subsidy decisions might also be informed by estimation of the *income elasticity of demand*. Briscoe et al (1990) found in a WTP study in Brazil that the income elasticity of demand for yard taps and public standpipes were quite different. Yard taps showed a positive income elasticity of demand, indicating that it the wealthier consumers would choose to install yard taps; whereas public taps revealed a negative income elasticity of demand and would therefore be used by the poorer consumers (this is also intuitively obvious). It would appear possible then, to cross-subsidise public tap supply (by charging a lower tariff) from the yard taps.

3.1.3.2 *Economic viability*

Lovei (1992) identifies four methods by which the economic viability of a project can be assessed. Economic assessment may be used during project appraisal stage, or to compare different projects to assess the best investment. The methods are listed in increasing thoroughness and desirability:

- (i) *least cost* (i.e. cost is the sole consideration): this is useful when the majority of project benefits are considered non-quantifiable or the benefits of different supply options are thought to be the same;
- (ii) *financial internal rate of return (FIRR)*: net present value (NPV) sums the predicted cash stream (discounted net revenue) over the project life based on estimated discount rates. FIRR is the percentage discount rate, which will result in zero NPV. Therefore, if $FIRR > \text{target discount rate}$ (representing the opportunity cost of capital) the project is financially viable. This method relies on financial viability to be the sole determinant of economic viability;
- (iii) *FIRR + consumer surplus*: inclusion of the consumer surplus gives some indication of economic benefits derived from the project; and
- (iv) *true economic analysis*: this would try to calculate the economic rate of return (ERR) through the use of a cost-benefit analysis. Many different methods could be used for trying to value project benefits.

Lovei (1992) recommends that ensuring the FIRR is at least the same as the discount factor (i.e. method ii) should be used as a minimum estimation of ERR — this should only be done if it is unfeasible to calculate ERR. It is this last method that is useful to discuss further, as this is conventionally how ‘true’ economic benefits are assessed.

3.1.3.3 Cost-benefit analysis

‘Cost-benefit analysis (CBA) is a practical way of assessing the desirability of projects...it implies the enumeration and evaluation of all the relevant costs and benefits’ (Barker, 1997b)

Project appraisal involves a comparison of costs and benefits. Two issues need to be considered when reviewing a CBA:

- *distribution*: whom does the project benefit and who pays the cost; and
- *efficiency*: is the net benefit greater than the net cost.

In RWS projects, capital costs will generally be financed by outside agencies — although there is a trend for transferring some of this capital cost onto communities through community contributions: either in cash or labour (Evans and Appleton, 1993). Benefits will accrue to the community and issues surrounding the distribution of these benefits need to be raised when designing, e.g. tariff structures, cross-subsidies and levels of service.

When evaluating efficiency, it is important to identify all costs, benefits and externalities (these may include technical externalities such as environmental impacts and others). All costs and benefits need to be projected as a ‘cash stream’ over the project life and discounted to their present values. The efficiency of a project, and consequently economic viability can be assessed if the net benefits exceed net costs.

Problems of valuation can be encountered in trying to value the benefits or the externalities. Often these will be imputed costs or opportunity costs and health or social benefits. Two benefits commonly used for RWS projects are valued in the following ways.

Time saving

A likely benefit from a RWS scheme will be that water is closer to the consumer, therefore there will be a time saving in collecting this water. One method of valuing this time is to consider what this time could potentially have earned for the collector (using the Marginal Productivity Theory of Wages — Barker, 1997b). Local agricultural labour rates are often used for this. If there is little available work in the area, the time may be valued at less than this rate. If there has been a decision not to work then the value of lost leisure time could be valued at the wage rate.

It has also been shown that consumption of water increases as the time to collect it decreases (Cairncross and Feachem, 1993). This can be used to compare the times used to collect water at a certain distance away and at the proposed cartage distance in the project to quantify the time saving. This can then be multiplied by the appropriate wage rate that is being ‘sacrificed’ to value the time saving. This must then be discounted to its present value and included as a benefit in the cost-benefit analysis.

Health benefits

The upgrading or construction of a RWS scheme is likely to have some impact on the health of the consumers — the relationship between water supply and public health has often been shown (WELL, 1998). However, valuing this benefit to include in the CBA is difficult. We need to consider either direct or indirect techniques to measure these benefits. If we choose to use direct techniques we need to try to find surrogate markets or experimental techniques (Pearce et al, 1989).

One possible surrogate market that could be used to value health benefits is to consider the reduction in water related diseases. This may translate directly into savings in trips to a local clinic or hospital for treatment or savings in the purchase of pharmaceuticals. Indirect methods could include ‘benefit transfer’ (by comparing the situation in one project with a similar project) and others (these will be discussed further in 4.2).

3.2 Approaches to financing

Development thinkers have responded to financing issues in a number of ways over the past few decades. As many projects had an engineering orientation, there was widespread belief that solutions to RWS problems lay essentially in technology (White, 1997). ‘Appropriate technology’ and VLOM (village level operation and maintenance) became popular ‘buzz words’ in the 1980s to address the problem, but technology alone cannot solve RWS problems (White, 1997). More recently, it is being realised that solutions lie more in bringing about social change and require full participation of the communities involved. Integrated development and community management are now seen as key factors affecting the sustainability of projects (Abrams, 1998).

Sustaining water supply systems requires the financing of capital and recurrent costs. As governments expand coverage of water supplies to meet shortages in rural areas, the demand for financial investment increases. As shown before, national budgets cannot realistically be expected to increase substantially for this purpose, nor can external support; therefore reduction in costs and financial contributions from users need to be used in tandem to finance these increasing costs (van Wijk-Sijbesma, 1988).

3.2.1 Financial objectives

The financial objectives of a WSP will differ depending on a number of factors, for example, whether the WSP is public or privately owned, government subsidy, the regulatory environment and the ability to meet demand. In SA, there will also be a range of financial objectives between different WSPs. Franceys (1998) suggests the following possible financial objectives:

- break-even: i.e. revenue generated = cost of supply;
- revenue maximising;
- revenue maximising subject to profit;
- profit maximising;

- return on fixed assets: this may be a set percentage of the fixed assets that is required annually to be generated from revenue. Other methods of generating earnings from investment may be a fixed return on capital employed.

Meeting basic needs as required by government policy and equitable use of government subsidies may also influence financial objectives.

Financing principles will affect financial policies and mechanisms. PDG (1998) suggest that managing water as an economic good has the following implications for financing principles:

- a) *finance policies* need to:
 - send out the correct signals to consumers linking service levels to actual costs;
 - maximise cost recovery by capturing communities WTP;
 - make efficient and equitable use of subsidies;
- b) *financing mechanisms* need to enhance communities' capabilities to manage, control and direct financial resources; and
- c) *communities* should choose the type of supply and level of service with the full knowledge of what they are expected to pay.

3.2.2 Subsidies

In many ways, policy debates regarding RWS amount to decisions on the best way to allocate government subsidies. As water is increasingly viewed as an economic good as well as a social good, thinking about subsidy is changing too. In economic terms, the reason that government intervention is needed in the financing of water supply at all, is due to 'market failure' (Pearce et al, 1994). In a properly performing market, supply would meet effective demand without outside intervention where effective demand is determined by willingness to pay. Market failure in RWS can be attributed to a number of factors, the most common being that consumers are not fully aware of the full benefits of supply. This may be due to (Lovei, 1992):

- benefits unknown to the consumer e.g. consumers not fully understanding possible health benefits of an improved supply; and
- benefits external to the individual i.e. accruing to the community e.g. transmission of disease within a community.

Because water is also a social good and subsidy issues cannot be considered in economic terms alone; political, social, financial and institutional issues will also influence the debate. In a recent World Bank conference advocating the use of the demand-responsive approach, the following guidance was given on the setting of subsidies (World Bank, 1998):

- Ideally, users should pay the full economic cost of supply i.e. no subsidies.

- However, if there is a subsidy, the financial arrangements should reinforce demand-responsiveness by:
 - uniform per capita subsidies (Garn, 1998);
 - subsidies should be set slightly below the average capital cost (over the country) of a basic supply;
 - there should be some form of cash cost-sharing of the subsidy amount with consumers; and
 - if higher levels are demanded, users should pay the full incremental cost of supply.

This is a radical view on subsidies, but believed to increase the sustainability of projects (Garn, 1998). Some economists believe that only when consumers are charged the full economic cost of supply will efficiency be achieved and hence market forces will be balanced.

Current subsidy policy in SA aims to provide a full capital subsidy for a basic level of service. This has effectively resulted in different per capita subsidies depending on differing costs of supply. The range of capital costs of RWS in SA are vast (see *Appendix 5.10*), and therefore setting a uniform per capita subsidy would have far reaching effects on levels of service and capital financing from users.

The subsidy policy proposed by the Consolidated Municipal Infrastructure Programme (see Section 2.1.4) of recurrent as well as capital subsidies is contrary to the demand-responsive approach and other international trends (World Bank, 1998). However, if these running cost subsidies can be used by the WSP (or WSA) for indirect costs relating to capacity building (or other overhead costs) they will arguably improve long-term sustainability (see PDG, 1998 for full discussion).

A major motivation for increased subsidies in the SA context is the political issue of redistribution of wealth to account for inequalities in subsidy levels in the past. This political and social objective is very important and cannot be overlooked when considering future subsidy policy.

Another factor in the subsidy debate is the externalities associated with water supply. Particularly the poor and ignorant consumers may be unaware of the full health risks of not using sufficient water.

3.3 Cost recovery

3.3.1 Principles

In most low-income countries it is very unlikely that the economic cost of RWS can be recovered in full from the beneficiaries (ODA, 1985). It may, however, be possible to charge some of the costs to beneficiaries. The most common starting point (and often end-point) is to charge users for the recurrent operation and maintenance costs (O and M) of supply (van Wijk-Sijbesma, 1988). The two main economic arguments for charging consumers for water are:

- equity:
 - users can pay according to consumption;
 - charging may provide a basis for allocation of subsidies;
- efficiency: the economically optimal allocation of resources is achieved, in theory, by setting tariffs equal to the marginal cost of production (Barker, 1998). This has environmental implications as well, if the true economic cost i.e. including environmental impacts are recovered; and
- expansion of coverage: funding shortfalls are often a major incentive in seeking cost recovery from customers. If users pay, more finances can be freed up to expand coverage to unserved areas.

The two main arguments against charging are:

- effect on use: water charges may cause consumers to consume an amount less than is needed to meet basic health requirements; and
- equity: unless the charging system is carefully constructed, water charges can easily result in increasing social inequities within a village by effectively pricing water out of the range of poor consumers.

In the SA context, there is a more compelling reason for charging for water: the necessity (through policy) to finance the recurrent costs of supply through user charges. It appears that government cannot afford (or does not choose to allocate finance) to pay the running cost of RWS projects (Jackson, 1998a). Therefore, *if users don't pay, who else will?*

Cost recovery issues are not simply financial. Ultimately, it is reliant on supportive government policy, institutional structures, systems able to bill and collect tariffs, and systems being constructed to meet consumers' demand and WTP. Implementing a policy of cost recovery requires acceptance of payment principles and consequently behavioural change (Hazelton, 1997). This last factor is complex; but essential to project success. RWS in SA in the past has effectively supplied 'free water'. Many communities today believe that water supply is a responsibility of government, and therefore should be free of charge (Mvula, 1998a). Adding to this problem is that most politicians in SA also believe that water should be given free to communities (Palmer, 1998). This makes the task of cost recovery very difficult for the WSP.

One strategy of the ANC during the 'struggle years' was service boycotts. It was part of a tactic of making the country ungovernable and thereby exerting control. The strategy proved effective, but today has created a 'culture of non-payment' of services. The ANC have recently tried to reverse this culture through an extensive campaign promoting

payment for services (Masakhane campaign⁴ — PDG, 1997), but it has had limited success.

3.3.2 Techniques

If cost recovery is required on a project, there are many mechanisms by which this can be achieved. Ideally the WSP and community should negotiate the most viable and appropriate cost recovery techniques. Some methods currently used are:

- contribution in kind: community members could reduce the cost of supply by providing free (or cheap) labour or other non-cash contributions;
- community fund raising;
- indirect taxes: this could be at a national or local level where water supply is subsidised through taxes. Water may also be charged through valuing other assets e.g. property value;
- water vending: water may be sold by entrepreneurial individuals in the community;
- regular user charges: it is these tariffs that are considered in this study; either:
 - flat rate: based on average consumption, household size, or other factors; or
 - charge per unit of water:
 - water bailiffs: may be used by the WSP to sell water at public standpipes e.g. 10c per bucket;
 - metered rate: this allows charging to be pinned to actual consumption. Meters have significant advantages (primarily equity and wastage) and disadvantages (mainly cost and practical reasons). The debate as to the use of meters is complex and will differ between situations (e.g. Lesson, 1998; WHO, 1994).

New and innovative cost recovery techniques are receiving increasing interest in SA. In a recent study of unconventional charging methods (Hazelton, 1997) it was found that electronic prepayment systems appear to have the widest application for public and private (individual) connections. Distributed storage technologies can also be used for individual connections or shared yard taps (see distributed storage tank developed in Kwazulu/Natal — Macleod, 1997). This can increase the individual's choice of level of service without the major expense of a full individual connection. It may be worthwhile establishing how payments are made for other goods or services within a community e.g. burial societies, to understand the cultural and social context.

The financing of connection costs may significantly influence cost recovery. Consumption and the likelihood of connecting to a new system have been found to decrease significantly when users are charged the full cost of connection (Altaf et al, 1992). In a mixed supply it may be feasible to finance different types of connections through different mechanisms e.g. public taps through the primary capital cost and individual connections through user charges. The availability of micro-financing institutions to enable

⁴ The Masakhane campaign was launched by the Department of Constitutional Development in 1996 to try to encourage payment for services

individual household's to access loan facilities will influence the success of this method (Mvula, 1998c).

3.3.3 Costs

If it is agreed that cost recovery is desirable (or necessary), the question then arises 'What costs?' should be recovered. There are three types of costs experienced over the life cycle of the project (Cotton et al, 1991):

- (i) *capital costs*: these may be financed through loans, but more frequently through grant financing;
- (ii) *recurrent costs*: engineers usually term these O&M costs. Economists generally use the terms fixed and variable costs (Zoiu, 1998). Variable costs will depend on the quantity of water produced e.g. fuel for pumping; and fixed costs will not e.g. operators wages, loan repayments (if any); and
- (iii) *replacement costs* (of any system parts).

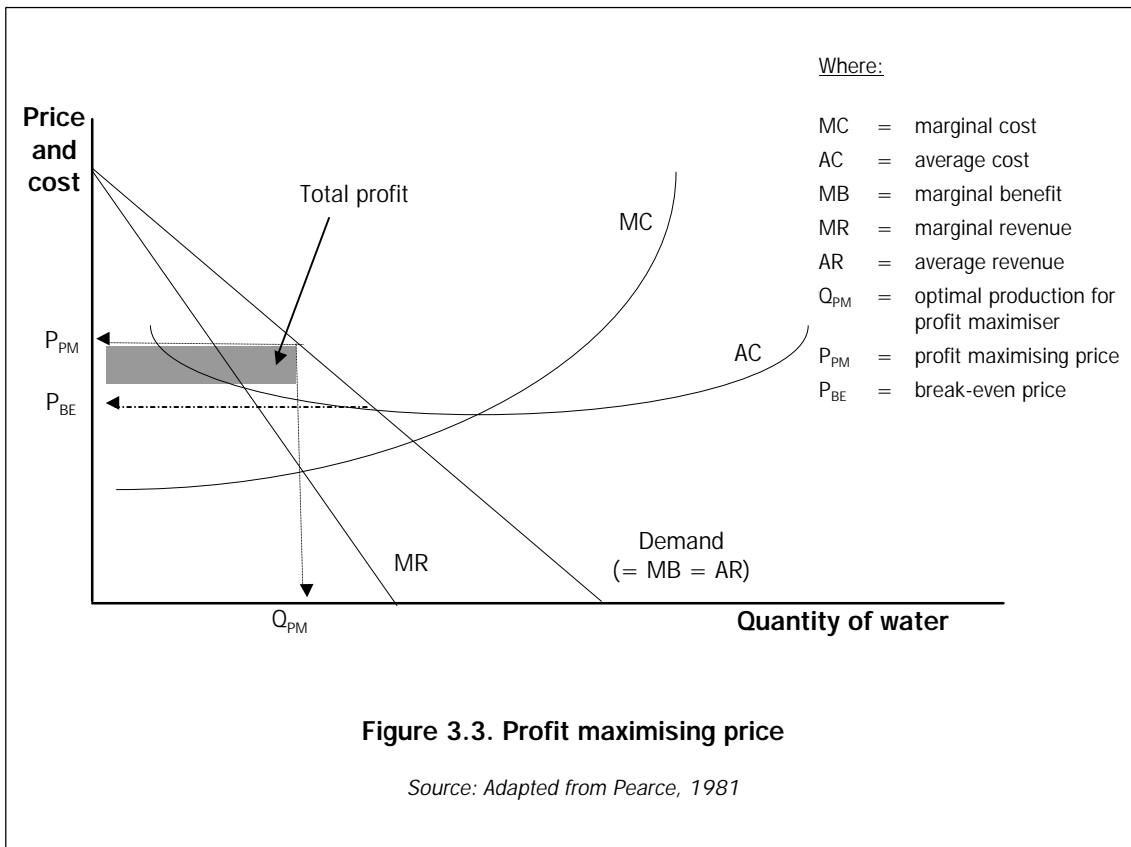
The cost of supply will include all of these components, however, they are incurred at different times over the project. Life cycle costing reduces these projected costs to their present value (using the discount factor) to determine the *equivalent annual cost*. The EAC can be used to calculate the required tariff for cost recovery.

The sum of the capital, recurrent and replacement cost of supply is termed the *total cost* of production. *Average total cost* is the total cost per unit of output. The *marginal cost* is the extra cost of producing an extra unit of output (Pearce, 1981). Mathematically, marginal cost is the first derivative with respect to output (quantity) of total cost. Economists distinguish between 'short-run' and 'long-run' average and marginal costs in order to show trends over a project life or from increased output.

Tariffs are set based on different costs depending on the financial objectives of the WSP. It is important at this stage to distinguish two different types of tariffs and to illustrate how they are represented on the demand/cost diagram.

3.3.3.1 Profit maximising

Profit maximising assumes that the WSP aims primarily to maximise profits. Profit is defined as the difference between total revenue received and total cost incurred. Marginal revenue is the slope of total revenue curve (and marginal cost the slope of total cost curve), therefore, profit maximising requires that marginal cost (MC) is equal to marginal revenue (MR) (Barker, 1998). Therefore, the profit maximising tariff is determined by the optimal output i.e. where $MC = MR$, where this intersects the demand curve. This simultaneously determines the profit maximising price. This is shown in Figure 3.4.

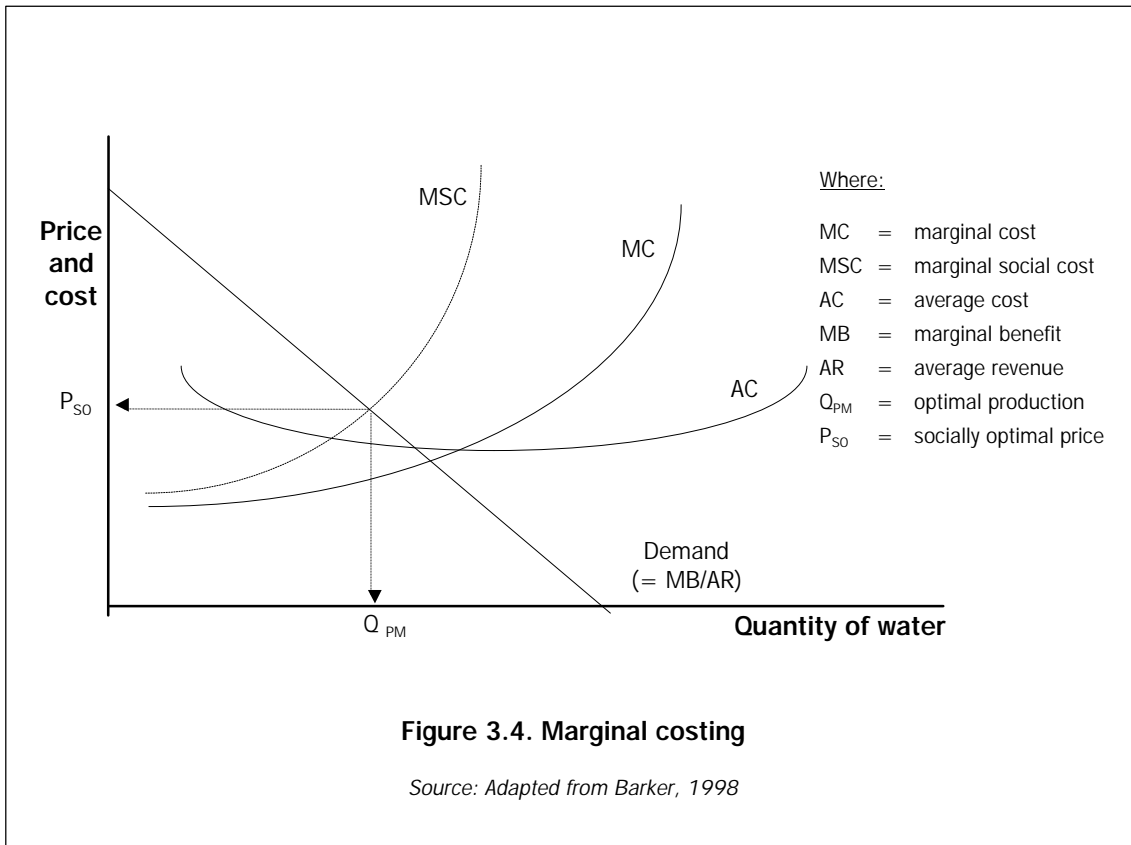


Total profit is shown in the shaded area. This is average profit (average revenue - average cost) x quantity. The break-even tariff (P_{BE}) is shown where average cost = average revenue.

3.3.3.2 Marginal costing

There is widespread agreement amongst economists that for economically efficient allocation of water, prices should be set on marginal costs (Barker, 1997a) i.e. where $MC = MB$ on the demand curve (see Figure 3.5); this is termed *marginal costing*. Providing the marginal cost has included all externalities (and could, therefore, be termed the Marginal Social Cost), the socially optimal price would be at this same point (P_{SO} in Figure 3.5). This means that marginal WTP is equal to resource cost.

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3.3.3.3

Average incremental cost

Marginal costing is often difficult to implement in water supply projects (Franceys, 1994) due to ‘lumpy’ increases in investment that are needed for future capital components. An accepted approximation to marginal costs that is currently advised by many economists (e.g. World Bank, 1998 and Barker, 1997a) is the *Average Incremental Cost* (AIC). This represents a ‘smoothed’ long-run marginal cost calculated over the project life. It is a forward-looking concept and effectively uses consumption as a proxy (or indicator) of benefit by calculating costs based on estimated consumption. AIC can be represented by the following equation:

$$\text{AIC} = \frac{\text{PV of costs}}{\text{PV of water produced}}$$

Present values are determined by discounting the cash flows and projected consumption quantities at the discount rate — which equals the opportunity cost of capital to the national economy (opportunity cost is the value of a resource used in the most desirable alternative — Begg, et al, 1984). Prices based on future cost (AIC or marginal cost) will

normally be higher than prices based on historical cost as the cheapest nearby water sources are used first (Franceys, 1994).

3.3.4 Tariffs

The ODA (1985) suggest that the decision to charge for water should be based on the answers to the following two questions:

- (i) Is it desirable?
- (ii) Is it technically, administratively and politically feasible?

Previous sections have shown that in the SA context charging for water is not only economically desirable, but financially necessary. It is the feasibility issue that is dealt with in this section. In theory, there is a vast number of tariffing options, influenced by a range of factors, and this can make decisions about tariffs very complex. Although ultimately, a tariff policy will be a political decision (Smout, 1998) and relate strongly to the financial objectives of the WSP.

If the decision has been made to charge for water, many questions need to be asked before adopting a tariffing policy, for example:

- Who is the WSP?: this will influence financial objectives, tariff policy, and the sophistication of tariff mechanisms;
- What is the national subsidy policy?
- Is cross-subsidy (between different types of consumers) politically, socially and economically possible/desirable?
- Cost recovery techniques;
- What costs need to be recovered?: O&M, depreciation, capital, interest on loans; marginal costing?; and
- discount rates, interest rates etc.

3.3.4.1 Objectives

Franceys (1998) sees the following four principle objectives of tariff setting (easily remembered by the acronym 'CAFES'):

- *Conserving*: setting water charges such that consumers purchase enough to meet basic needs without being wasteful (environmental);
- *Adequate*: to meet financial objectives of WSP (financial);
- *Fair*: charges need to set to protect vulnerable user groups (equity); and
- *Enforceable* and *Simple*: simple to administer and easy for consumers to understand.

Charging for water depends to a large extent on the level of service supplied. The ODA (1985) suggests that approaches should distinguish between piped and non-piped supply systems when considering appropriate charge mechanisms. A central issue informing a charging policy is whether a system can be controlled or not. This study considers piped water supplies with a mixed level of service. This will presumably require different charging mechanisms for different levels of service.

3.3.4.2 Options

Options for recovering costs that are currently used are (adapted from Cairncross and Kinnear, 1988 and Franceys, 1990):

- a) zero tariff: water subsidised through other means;
- b) tariffs set on assumed ability to pay (affordability) or some other socio-economic factor. This ignores the actual cost of supplying the water — it is often used in a supply-driven approach;
- c) increase some existing tariff modestly in line with inflation;
- d) recovery of O&M costs;
- e) O&M plus depreciation of the assets: this can be seen as a ‘replacement fund’ to finance future capital investment;
- f) O&M plus full amortisation of past investments (i.e. capital costs + interest on loans + depreciation);
- g) target rate of return on fixed assets (ROFA): this is a means of charging based on **historical costs**; and
- h) average incremental costing: charging based on **future costs**.

A significant factor affecting tariff policy will be the extent to which **cross-subsidy** between consumers is desirable and possible. Issues that need to be considered are:

- the range of levels of service offered, and the estimated demand of each LOS: if only a small proportion of consumers are likely to connect to a high LOS, will sufficient funds be generated by the additional revenue to be able to subsidise the lesser consumers?;
- the price elasticity of demand: if higher consumers are charged higher prices, demand and total revenue may decrease;
- consumers: different types of consumers e.g. domestic and institutions can be distinguished and charged differently.

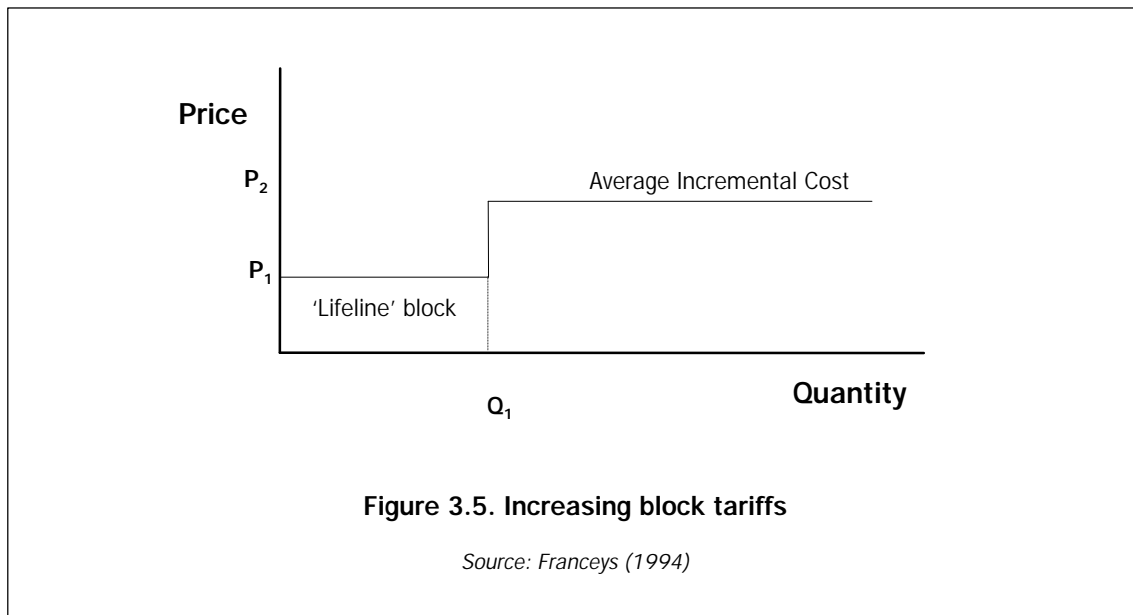
Katko (1991) distinguishes between the following types of tariffs used in the water sector:

- flat rate: tariff is invariant by consumption;

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- uniform rate: tariff increases uniformly with respect to consumption;
- decreasing block tariff: tariffs decline in 'steps' as consumption increases; and
- increasing block tariffs: tariffs increase incrementally as consumption increases.

This last method is what many donor agencies have recommended over the past few decades (Whittington, 1992). An adaptation of the increasing block tariff, is to set the initial tariff on some affordability criteria, to ensure that desired public health requirements are met. This is termed a 'lifeline tariff' and is illustrated in Figure 3.6. Franceys (1994) recommends a rationalised approach to tariffing: where lesser (poorer) consumers are charged a lifeline tariff and higher consumers are charged the full average incremental cost of supply (Figure 3.6).



Where:

- P_1 = tariff set on affordability;
- P_2 = tariff set on average incremental cost; and
- Q_1 = consumption set at some value related to minimum public health requirements (e.g. 4 to 6 m³ per family per month).

4.

Demand Assessment

Chapter 3 investigated some current approaches to cost recovery in rural water supply projects. It was shown that tariffs need to be designed in order to meet the financial objectives of the WSP. This will be influenced by government policy regarding subsidies. Tariffs should be set based on willingness and ability to pay, as well as the cost of supply.

The term ‘demand’ has different meanings to different people. These differences are not necessary misuses of the term, but nevertheless have very different implications for project design. Three distinct interpretations of demand are used by different stakeholders within the water sector:

- a) *felt needs*: Often the ‘felt needs’ or aspirations of communities are equated with demand. An adequate water supply is defined as a basic human need in SA (ANC, 1994) and communities (and often politicians) usually have a strong idea about what level of service is appropriate to meet this demand (Mvula, 1998a). Projects are often motivated solely by meeting this need (particularly within a supply-driven approach) on equity or political grounds;
- b) *consumption*: Engineers, planners and designers have traditionally equated demand with consumption based on level of service e.g. 30 l/c/d for a standpipe supply (see Table 5.3) or on minimum health requirements. Payment for services is often seen as a separate issue and not directly related to this demand. This definition is also often used in a supply-driven approach where water demand is seen as a function of various environmental factors (e.g. income, tariff, household size etc.);
- c) *effective demand*: Effective demand (term used by White, 1997; Merrett, 1997, and others) is generally assumed when ‘demand’ is discussed in economics (Stiegler, 1985).

Sen (1981) illustrates effective demand by considering a shop selling food in a famine area, where many people cannot afford to buy the food. The need for food is great, but only a few people can afford to buy it, therefore, effective demand for food is small. It is important, for this study, to define the term more precisely. Pearce (1981) defines effective demand as:

'aggregate demand for goods and services which is backed up with the resources to pay for the...distinguished from 'notional demand' which refers to a desire for goods and services'.

It is this definition of demand that is used in this study (this is supported by other authors, although there is slight discrepancy in the literature as to the definition). Some literature refers to 'economic demand' as having this meaning. Hibbs (1993) argues that the concept of effective demand is only meaningful if the demand is supported by willingness to pay (WTP). The interpretation of demand as WTP is central to the arguments in this report.

Unfortunately, WTP is by no means simple to assess (ODA, 1985), but of late, reliable demand assessment is receiving higher priority in development projects (Pearce et al, 1994). This chapter explores some ideas about effective demand, investigates current 'demand assessment techniques' and considers the 'demand-responsive approach' as a framework for project design.

4.1 Effective demand

4.1.1 Ability to pay

The traditional method for assessing how much consumers should pay for water has been based on their *ability to pay* (ATP) (Churchill, 1987). This is a measure relating the cost of supply to income and therefore the *affordability* of the system. Standard percentages of income are assumed to be within an affordable range of the consumer. These percentages have been used as a rule-of-thumb by many designers: figures of between 3 and 5% are commonly used (Franceys, 1998). For urban supplies, ATP is often assumed to be 4% (ODA, 1985).

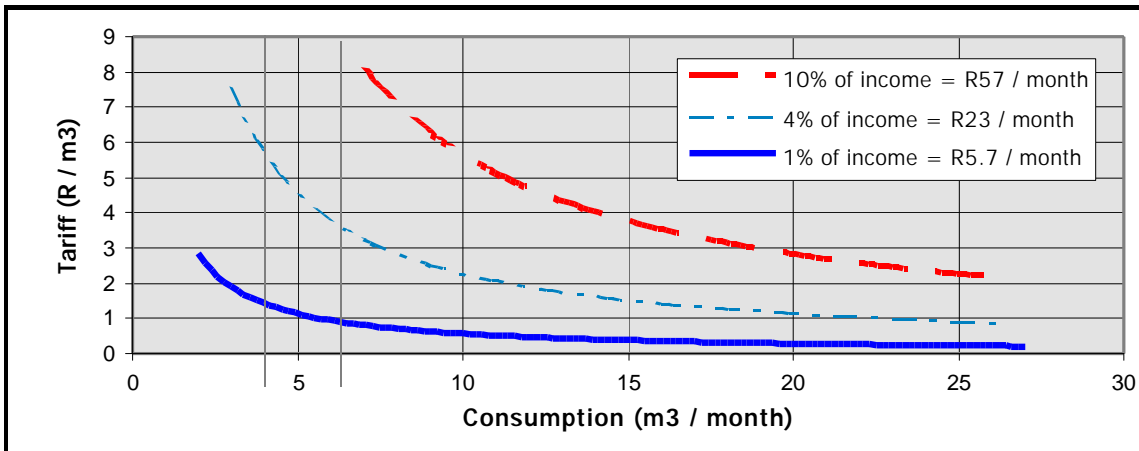
Four main factors affect ATP:

- (i) the cost of supply and tariff;
- (ii) average income and income distribution;
- (iii) percentage of income spent on water; and
- (iv) average consumption per head.

The interplay between these factors generates a complex range of alternatives (ODA, 1985), however, they may be represented fairly simply in a graph. Graph 4.1 shows the possible relationship between tariff and consumption for different percentages of income. One major shortfall of this representation is that it assumes an average income for the village (this is assumed to be R567/house/month — from figures of disposable income in the Northern Province of SA (1993 figures) — PDG, 1996). This graph would be improved if the range of income within the village were known: the y-axis would then reflect the percentage of householders ATP at different percentage of income, however, the consumption would then need to be fixed (ODA, 1985 p35).

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Graph 4.1. Ability to pay



Note:

- These curves assume unit elasticity of demand with respect to price (i.e. $E_d = -1$) (this implies that consumption is dependant solely on income), therefore if the tariff is increased by $x\%$, consumption will decrease by $x\%$. Unit elasticity is represented as a hyperbola on a demand curve (Franceys, 1998).
- A family should consume between approximately 4-6 m³/month (as indicated by the vertical lines) in order to satisfy minimum public health requirements (WHO, 1992): this would indicate a maximum tariff of around R4/m³ in order for an average household to pay 4% of their income towards water.

Income — and income distribution — is often very difficult to assess, particularly in rural areas. Some surveyors in SA have found that householders are often unprepared to declare monthly incomes (Timm, 1998). This may be due to the amounts not being known e.g. if the family relies on the wages of a migrant worker; a reluctance to reveal the information; or a non-cash based economy. In these cases it may be useful to use proxy indicators of income. PDG and others (e.g. Mvula, 1998c) have used ‘appliance schedules’ (a list of appliances in a dwelling), as proxy indicators of wealth. The amount that householders are prepared to pay to water vendors has also been used to indicate ATP — this will be discussed more extensively in the next section.

Many figures for ATP have been derived from actual behaviour i.e. measuring what consumers actually pay for water. This historical observation is less useful for planning or designing where the engineer needs to predict payment levels corresponding to different levels of service before the project is implemented. It is also questionable whether ATP in one area will necessarily be the same in another (benefit transfer) (Pearce et al, 1994).

This report does not recommend that tariffs be based on ATP, however the author does believe that relating tariffs to income is useful to the designer. It may not predict actual behaviour accurately, but it does inform the complex debate over tariffs.

4.1.2 *Willingness to pay*

Ability to pay is an attempt at setting tariffs related to the affordability of supply. However, the issue more central to financial sustainability is predicting what consumers are actually going to pay for water — this indicator is commonly termed ‘willingness to pay’ (WTP). WTP in economic terms is the maximum value that consumers attach to a commodity within the prevailing conditions (equatable to demand). The term ‘willingness’ can be confusing (in a non-economic paradigm) as consumers may not be ‘happy’ paying a certain tariff; but they are prepared to pay this amount *rather than go without*. Another term sometimes used for WTP is ‘willingness to accept’ (Pearce et al, 1994). This conveys the literal meaning of the term better, where the necessity for consumers to pay for services has been a political decision, as in SA. WTP in the context of this report can be equated to effective demand. Research relating WTP to the proportion of cash income that this represents have shown a range between 0 and 10% (DFID, 1998).

Examples of differing WTP are (adapted from WELL, 1998):

- people are WTP 1.3 to 2.3. times more for a yardtap than for water from a standpost;
- women are 40% more WTP for standpost supplies than men;
- in Khartoum, the poorest were paying 56% of their income for water at a rate 120 times as great per cubic metre as the rich were paying;
- in rural Thailand, villagers were WTP 8-9% of their income for yardtaps, but were unwilling to pay small amounts for maintenance of communal supplies;
- in Chihota District in Zimbabwe, where water is relatively easily available from traditional wells, WTP is very low (0.5% of income).

Section 3.1.3 described the methodology commonly used to assess economic viability viz. cost-benefit analysis. CBA attempts to value the benefits of a project in order for government (or donor agencies) to make investment decisions — improvement in public health is typically the major benefit. Beneficiaries, however, may perceive the benefits of an improved water supply to be quite different: convenience, status, cost and time-saving may be more significant (WELL, 1998; Briscoe and de Ferranti, 1988). WTP is measure of these perceived benefits. In effect, it is equivalent to beneficiaries making their own investment decisions (whether to connect to a new supply or not) based on perceived benefit. However, Lovei (1992) points out that relying solely on consumers WTP to indicate project benefits ignores to two possible benefits:

- benefits *unknown* to the consumer e.g. consumers not fully understanding possible health benefits of an improved supply; and
- benefits *external* to the individual i.e. accruing to the community e.g. transmission of disease within a community.

In these cases, **demand creation** may be necessary. This is a particular problem with demand for sanitation, in particular excreta disposal systems. Demand creation may include sanitation promotion or health and hygiene promotion.

In economic terms, basing tariffs on WTP is a means of matching supply with demand. If demand is varied i.e. due to varied WTP within a community, it seems inevitable that a mixed (or varied) level of supply needs to be offered. This allows consumers to choose between different supply options the type of service for which they are willing to pay. This range of facilities is termed *levels of service* (LOS) and for a water supply would typically be dictated by the distance of the supply from the consumer.

4.1.3 Determinants of demand

Until recently, little research has been done into the factors affecting rural communities WTP for improved water supply services (Garn, 1998). These ‘determinants of demand’ will vary between projects, areas and countries (World Bank, 1993). Projects where household income alone has been assumed to be the overriding determinant of demand (ATP method) have often provided surprising results as to the actual amounts people are prepared to pay for different LOS. Green (1995) found that villagers in Uganda were prepared to pay significantly higher tariffs for the LOS that they wanted rather than the lesser amount for a LOS that they did not. This view is supported by many researchers (e.g. Lovei, 1992; Franceys, 1998; WELL, 1998).

Economists have attempted to establish a theoretical functional relationship between water demand and the determinants of demand (Section 3.1.3 outlined various models that have been used e.g. $Q_w = f(P_o, P_w, SE)$). The most extensive empirical research in this area has been conducted by The World Bank in a number of continents predominantly between 1987 and 1990 (World Bank, 1993). Although there was found to be a substantial range of factors influencing demand (and variation in significance) the following three factors were found to have the greatest influence on demand (it is not known which of these is the most important) (adapted from World Bank, 1998):

- a) *socio-economic characteristics*: household income, gender, education, occupation and assets, among other local demographic characteristics;
- b) *characteristics of supply*: the relative merits of the proposed water supply (over the existing source), particularly relating to cost, quantity, quality and reliability; and
- c) *households' attitudes* towards government policy and the water service provider.

The first category of influences relates closely to traditional methods of assessing ATP. Van Schalkwyk (1996) combines these factors (and a host of others e.g. household size, type, customs, migrant workers etc.) into a ‘level of living index’. Dearden (1997) found gender to be a significant determinant of WTP, although whether women’s valuation was more or less than men’s depended on the local context. Although most researchers acknowledge the relevance of these factors, the direct link between WTP and demographic characteristics is somewhat spurious (Davis and Whittington, 1997).

The second category is undoubtedly very significant (this is agreed across the literature); particularly the price of the new supply. Poor households, without good alternative supplies, are often willing to pay (relatively) more for improved supplies than richer families with good existing supplies (WELL, 1998). The notion of ‘coping strategies’ i.e. what people would do without the improved supply, is important in this category. CBA tries to value this benefit difference — between existing and proposed supply. In case studies in South Asia, the actual connection cost had a major impact on demand (DFID, 1997). In Kerala, India the difference between the connection cost being charged as a lump sum or being amortised (in instalments) into the bill was significant to connection rates and total revenue (Griffin et al, 1995). The impact of tariffs on demand (price elasticity of demand) is possibly the most recorded variable, particularly in the developed world (Franceys, 1998) and is also very significant in projects in SA (Hazelton, 1997).

It is the last category of influences which has until recently been relatively unexplored, and which is increasingly being found to be of major significance. Waughray (1998) in a study in Zimbabwe found that the major influence on WTP was the impact of government Structural Adjustment policies. Communities' acceptance of cost recovery principles significantly increased after structural adjustment had been implemented and consequently payment for services improved.

It is the author's opinion (and shared by many colleagues) that it is this last category which has most resonance in South Africa. Chapter 2 cited cases where perceptions regarding the ‘legitimacy’ of charging for water supply severely hampered payment levels (PDG, 1998; Mvula, 1998). Government policy regarding payment for water supply has changed dramatically over the past few years. The old regime effectively supplied ‘free water’ to communities and the RDP sent out confused signals: declaring water to be a basic human need, and not stressing explicitly that it needed to be paid for by consumers. The current major economic policy, GEAR (Growth, Employment and Redistribution) has ‘borrowed’ many principles from structural adjustment, but there is no evidence, as yet, that it has had any direct influence on payment levels.

4.2 Demand assessment techniques

The importance of matching level of service with demand (or WTP) has been shown by many researches (e.g. Lovei, 1992; Whittington and Choe, 1992), however with so many factors influencing WTP, demand is notoriously difficult to assess (Franceys, 1998). This section investigates some of the *demand assessment techniques* that are currently used in water supply projects.

Demand assessment (or *economic valuation*) has been used primarily by environmental economists in order to value environmental goods. Methodologies have been developed to assign economic value to non-market goods — these involve determining how much better or worse households would be if they were able to use some specified level of

improved service (Pearce et al, 1994). The economic value of a service is defined as the amount consumers are willing to pay to obtain it.

In water supply projects, the principle interest of a designer or planner is predicting the proportion of people that will connect to the new supply at given tariffs. Therefore the designer needs to rely on models designed to predict household preferences or consumer behaviour. Demand assessment, in effect, can then be thought of as an attempt to estimate the demand curve for water supply.

Demand assessment has rarely been applied to water supply projects, and even less in low-income countries (Pearce and Moran, 1994). Established demand assessment techniques can be broadly categorised into two methods:

- *direct methods* (stated preferences): where people are actually asked what they are willing to pay for an improved supply; or
- *indirect methods* (revealed preferences): where consumer behaviour is predicted through other means.

This study does not investigate all the techniques in detail. Much of the referenced literature covers the subject more thoroughly. A key text on the subject is ‘Guidance notes for DFID economists on demand assessment in the water and sanitation sector’ (DFID, 1998). It offers guidance on selecting demand assessment methods and details the contingent valuation and revealed preference methods. Dearden (1998) also gives a good overview of some possible applications of demand assessment.

4.2.1 Direct methods

Direct valuation methods involve asking people directly to state their preference for a certain improvement in specified environmental quality. Hypothetical options (in terms of quality, level of service, reliability and price) are presented to people and they are asked to indicate what choices they would make. This process can be done individually through the use of survey processes — the *contingent valuation method* (CVM) or contingent ranking method; through community meetings or using various PRA (Participatory Rural Appraisal) techniques. One of the major reasons a direct valuation methodology is used for water supply projects is that it tries to capture the total economic value attached to the service. Indirect approaches may undervalue the true total economic value households attach to the supply e.g. reliability may be a significant benefit which indirect approaches may fail to value (Waughray, 1997).

The literature yielded little information on community meetings and other PRA techniques, however a report by Davis and Whittington (1997) makes an interesting comparison between direct valuation techniques using community meeting approaches and CVM, used for a demand assessment exercise in Lugazi, Uganda. Similar hypothetical scenarios were posed to groups (in the community meeting approach) and individuals (using CVM) in an attempt to elicit WTP for a proposed water scheme. The research found that although data collected from the CVM was more robust i.e. a smaller range

of findings, the policy recommendations for both techniques were the same. It was also difficult to assess which technique was more accurate. This section, however, will concentrate on CVM.

4.2.1.1 Contingent Valuation Method

Contingent valuation (CV) as a method of direct valuation of improved water supplies has received increasing attention from donor agencies, policy-makers and practitioners over the past decade (Pearce and Moran, 1994). It has been the favoured demand assessment technique used in low-income countries for watsan projects (Pearce et al, 1994).

CVM is a survey technique that attempts to elicit information about individuals' (or households') preference for a good or service. Householders are asked questions about hypothetical supply options (hence the term 'contingent') from which they must indicate the amount they are willing to pay for various levels of service.

There are many extensive texts on CVM (e.g. Pearce et al, 1994) and reports on WTP surveys (e.g. Altaf et al, 1992; WASH, 1988). In depth analysis of the technique is outside of the scope of this report, but it is useful to briefly consider the basic methodology, some of the biases implicit in the method and some case studies.

Methodology

The accepted best practice for designing CV surveys has been published by the US National Oceanic and Atmospheric Administration (Griffin et al, 1995). There are three basic parts to most CV surveys (Pearce and Moran, 1994):

- a questionnaire is developed outlining different hypothetical scenarios (of varying LOS, or other characteristics of supply);
- respondents are asked structured questions to determine the maximum WTP for certain supply options. Questions could be referendum type (i.e. yes or no) or some form of 'bidding game' (the enumerator will increase or decrease bids incrementally until the respondent reveals his/her maximum WTP). This data is then 'cleaned' in an attempt to minimise biases. The data is analysed to varying degrees of sophistication. Econometric models are used to infer an aggregate WTP for the service and a mean WTP bid at specific levels (e.g. R x /m³); and
- these values are then related to socio-economic and demographic characteristics in order to test the validity of the responses (correlation is a good indication of meaningful responses).

Biases

CVM is subject to a number of biases, intrinsic in the technique. It is essential for the researcher to be aware of these biases and 'clean' the data to minimise their impact (Briscoe et al, 1990). Waughray (1997) lists the following biases as most significant:

- hypothetical bias: respondents misunderstand the hypothetical market;

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- strategic bias: respondents understating their WTP in the hope of a ‘free ride’ or overstate their WTP to ensure a public good is provided;
- compliance bias: whereby respondents give answers influenced by the desire to please the enumerator;
- embedding: respondents interpret hypothetical offer of a specific good or service as indicative of an offer for a broader set of similar services; and
- starting point bias — where final WTP bids correlate to the opening amount offered.

Different techniques have been developed to attempt to minimise the impact of each of these biases (see DFID, 1998).

Case studies

The following three case studies have been selected to illustrate different findings.

(i) World Bank Water Demand Studies

Between 1997 and 1990 the World Bank embarked on five major demand assessment studies in South America (Brazil), Africa (Nigeria and Zimbabwe) and South Asia (Pakistan and India). All used indirect (revealed preferences) and direct (CVM) methods of assessing demand. The studies are recorded in the following reports (listed in the reference list and select bibliography):

- Brazil (Parana and Ceara): Briscoe et al, 1990;
- Nigeria: Whittington et al, 1991;
- Zimbabwe: Robinson, 1988;
- Pakistan (Punjab): Altaf et al, 1992; and
- India (Kerala): Ramasubban et al, 1989; later in a follow up exercise: Griffin et al, 1995.

Key findings from the study and cross-cutting themes have been produced by The World Bank Water Demand Research Team (1993). One of the key findings of the research are the generalised determinants of demand as discussed in 4.1.3. Another, was to separate villages into four types, that each require a different policy approach:

- Type 1: High WTP for private connections; low WTP for public taps;
- Type 2: A few will pay the full cost of private connections; the majority will pay the full costs of public taps;
- Type 3: Households are WTP for improved services, but improvement is very costly; and
- Type 4: Low WTP for improved water sources.

Type 4 villagers pose difficult social and political challenges for government. Type 1,2 and 3 villages require innovative design and cost recovery mechanisms to be able to satisfy demand. Applying different policy to different villages depending on these classifications may be impractical, but it may still be useful to make these distinctions.

(ii) Kerala, India

A CVM study was conducted in Kerala in 1988 to ascertain WTP for household connections to a piped water system. In 1991, the families in these same communities were surveyed again to investigate the actual decisions they had made. This case study is documented in ‘Contingent Valuation and Actual Behaviour’ (Griffin et al, 1995). The case study is interesting as it sheds light on an issue central to evaluating CVM viz. *benefit revelation* i.e. did people behave as they said they would? (or as the study predicted).

The study concluded that CVM was a valid and reliable demand assessment technique under very specific conditions (this is stressed in the report). Some interesting results from the study are:

- CV studies need to be very carefully designed and conducted to elicit meaningful results — this requires significant (does not give actual figures) time and money;
- most significant bias in CV studies arise from hypothetical bias; and
- WTP questionnaires should be connected as closely as possible to actual costs.

(iii) Community garden programme, Zimbabwe

CVM was used to help design tariffs for a community well garden programme in Zimbabwe (Institute of Hydrology, 1998; Waughray, 1997). Some findings from the study are:

- CVM is a useful tool for predicting WTP;
- WTP bids did not correlate as expected to some of the respondents socio-economic characteristics;
- focus groups were used in a pilot study prior to the main study to estimate starting bids for the bidding games — this increased the reliability of the survey;
- PRA techniques were used alongside CVM to provide qualitative as well as quantitative information on WTP; and
- WTP was assessed for different months of the year — significant seasonal variation in WTP was revealed (roughly inversely proportional to rainfall).

Applicability of CVM

The validity and reliability of CV studies for assessing water demand has been hotly debated (Griffin et al, 1995). It is agreed that some ‘quick and dirty’ WTP surveys in the past have yielded non-sensical results (Saunders and Warford, 1972). Many economists (and others) share this scepticism today, principally as they don’t believe that many

people understand the real economic value of water (Waughray, 1998). CV techniques, however, have been significantly developed and do appear to be useful in certain contexts (DFID, 1998). WELL (1998) propose that the case for using CVM at some stage rather than just revealed preference studies is stronger when:

- there is a range of LOS options from which consumers can choose;
- there is a range of WTP across different users, and consequently the possibility of cross-subsidisation;
- house connectors are willing to pay the full cost of supply and are likely to ‘sell water on’ to their poorer neighbours; and
- the financial viability of the utility is dependant on cost recovery from consumers.

Many of these factors will be applicable to mixed levels of service in RWS in SA. Most researchers believe that to elicit meaningful results an economist experienced in CVM needs to design and interpret the survey (DFID, 1998; Griffin et al, 1995). This takes fairly significant amounts of time and money: DFID (1998) estimate £50,000 for an inexpensive CV study; £140,000 for a higher quality study; and a minimum of three months to conduct. These costs consist largely of three components: personnel costs of international consultant, international travel cost, and cost of local consultants field work. In addition, the task of establishing WTP through CVM is separate from the task of tariff setting — DFID (1998) believe that this requires further processing of the survey results.

4.2.2 Indirect methods

Indirect methods are those techniques which seek to elicit preferences from actual, observed, market-based information of some related goods or services or indicators of demand (Pearce and Moran, 1994). This includes a broad range of methods of predicting demand, many recorded in economics (and environmental economics) literature, and others not.

4.2.2.1 ‘Conventional’ economic methods

Indirect methods recorded in the literature can be subdivided into:

- observing behaviour: e.g. a rule-of-thumb ATP figure could be used from observed payment levels on a similar project;
- surrogate markets: consider markets which are related to water supply (as water supply is generally a non-market service). Methods using surrogate markets include hedonic pricing (implicit or ‘shadow price’) and travel cost models. These methods have rarely be used in water supply projects (Pearce et al, 1994); and
- estimating benefits: three benefits that have been used to establish demand are (WELL, 1998): health benefits, time saving (as described in 3.1.3), and financial cost saving. The last method involves calculating the cost saving an improved supply may

have on household water expenditure e.g. the cost saving from not having to boil water of poor quality.

4.2.2.2 *Other methods*

Any measure used by designers to indicate predicted demand could theoretically be termed a demand assessment technique. Few of these have credibility amongst economists and other theorists, but could arguably be valid attempts at economic valuation. Two other indirect approaches currently used are:

Water vending studies

The practice of water vending is very common in low-income countries: an estimated 20 to 30% of the urban population and a significant proportion of the rural population are served by water vendors (Caincross and Kinnear, 1988). It has generally been found that the price people are prepared to pay for vended water is significantly higher than tariffs charged by 'formal' suppliers (Franceys, 1994).

Some examples of what consumers are actually paying for water are (WELL, 1998):

- The average African tariff is \$0.25/m³; although the suspected average cost is \$0.75/m³ (World Bank, 1990);
- In Lima, Peru, water vendors sell water for \$3/ m³ which is TEN times the cost per cubic metre paid for by rich households with connections;
- In Dominican Republic water subsidies for the richest 20% are FOUR times higher than subsidies for the poorest 20%.

This vended water is effectively a surrogate market that could indicate WTP for a piped water supply. Very high unit costs are quoted for some vended water (e.g. \$3/m³ in Lima, Peru — WELL, 1998), but cognisance must also be taken of actual consumption, and therefore actual monthly expenditure. Water vending studies have been used extensively to assess demand for improved supplies (they rely on calculating the financial cost saving as with revealed preference surveys). DFID (1998) conclude that if water vending is extensive and the cost saving to a household from an improved supply is large (this would generally be the case), demand for improved services is almost always high.

Community participation

An example of an agency that uses community participation to illicit demand is the Mvula Trust. Mvula has a prerequisite for project funding of a 'cash contribution' from the recipient community to be collected before the project is approved. This cash amount should be linked to the predicted O&M costs of the system for the first few months of operation (Palmer, 1998). The motivation for this procedure is to emphasise cost recovery principles from the outset, but also to assess the willingness of householders to contribute to the scheme (and the ability of the WSP or village water committee to be able to collect this money). In this respect, these up-front cash contributions could be seen as indicators of WTP and therefore a means of assessing demand.

The initial policy of the Trust required communities to make up-front contributions to the capital cost of the project. This was an attempt to encourage payment for water and to assess the willingness of the community to pay for the O&M of the new supply. An external evaluation of the Trust (Blaxall et al, 1996) revealed that the connection between contributions to the capital cost and WTP for running costs was not realised by the community, and the failure of communities to collect this capital contribution was not necessarily an indicator of WTP. The policy subsequently changed to link community contributions directly to running costs.

4.2.3 Selection of demand assessment method

Assessing demand based on WTP is extremely difficult. There is no doubt that some form of demand assessment is necessary in order for project to be designed to meet demand, however there are no clear cut rules as to which demand assessment technique to use in different circumstances. What is clear, is that the designer will never know, with complete certainty, how many m³/day is demanded for any proposed water supply. Different methods have been used with varying success in the past. DFID (1998) assess the pros and cons of six direct and indirect methods against applicability, time and money cost and perceived accuracy of the method. This last category separates the views of environmental economists, water resource engineers and planners, and policy makers/politicians and reveals interesting comparisons. Revealed preference methods are generally accepted by economists whereas cost saving approaches are preferred by engineers and policy-makers. CVM is regarded as controversial (although elsewhere in the document it is recommended).

'In general, economists prefer estimates of economic value based on what people actually do, rather than what they say they will do' — DFID, 1998

WELL (1998) also makes a comparison between six demand assessment techniques. The comparison favours community PRA-type techniques for small rural projects and the use of CVM for larger infrastructure investment programmes. They also propose that two approaches to demand assessment that are **not** recommended are:

- affordability rule-of-thumb i.e. ATP as a percentage of household income (4.1.1); and
- benefit transfer: where it is assumed that the demand assessed in one location can be replicated to another similar location. Demand has been found to differ considerably over seemingly similar locations and therefore the conditions under which benefit transfer is valid are rigorous and infrequently met (Griffin et al, 1995). This has implications for the replicability of demand assessment methods.

DFID (1998) make the following conclusions regarding the selection of demand assessment methods for small rural water projects (they are very similar to conclusions derived as a result of the research done for this study):

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- the cost of a CV study will generally not be justified at project level, however CVM may be useful to inform policy;
- proxy indicators of demand such as water vendors and time saving can be used;
- community participation will help a scheme be demand-responsive particularly in:
 - design and implementation;
 - selection of technology;
 - determining arrangements for O&M; and
 - decisions concerning cost recovery.

The literature targets readers familiar with market research and economic principles and suggests methods that can assist in changing policy for large projects. DFID (1998) makes a clear distinction between the exercise of establishing WTP and using this information for design. Also the link between findings from WTP surveys and actual tariff setting is not clear in the literature.

Ultimately, there will need to be some trade off between the budget needed for accurate demand assessment, the estimated costs of the improved supply and the predicted usefulness of the results. Existing information regarding the area (e.g. payment level, income etc.) will also influence this decision.

4.2.3.1 Demand assessment in SA

It is difficult, and perhaps inappropriate to recommend specific demand assessment techniques for RWS in SA. However, it is an area which has been greatly overlooked in the current debate and it is the authors' opinion that some form of demand assessment is better than nothing at all. A pragmatic approach may need to be taken, which incorporate demand assessment into policy and project design. The following comments may assist in informing this debate:

- demand assessment techniques are not mutually exclusive (DFID, 1998): different methods can (and should) be used in tandem. Validity of findings should be enhanced by complementary use of different techniques (Davis and Whittington, 1997; Pearce et al, 1994);
- realistically, the type of demand assessment technique used is going to depend on the size of project and institutional arrangements: larger settlements (with big investments) will require increasingly sophisticated valuation methods e.g. CVM; whereas small villages will require less rigour. It would be sensible to use PRA techniques in villages where the future water supply will be managed at a community level;
- there is little data available to review the specific application of CVM in SA. Many researchers (e.g. Jackson, 1998b) are sceptical as to the use of hypothetical questions in the SA context (due to hypothetical, strategic and compliance biases) and little attention has been given to other techniques. It appears that a thorough CV survey would be too expensive for most RWS projects in SA.

Demand assessment attempts to predict the initial demand for water. As described, this is a complex and often unrealistically expensive endeavour, however what does seem to be of utmost importance, is for water supply systems to be designed to be able to respond to demand over the project life. WSP need to elicit and respond to demand on an on-going basis in order adequately address consumer needs. This approach has been termed the demand-responsive approach and is defined in detail in the next section, but as far as demand assessment is concerned, the following issues are important:

- design needs to be able to cater for communities and households choice as to the type of water system and LOS; and
- projects need to be implemented with minimum capital outlay until effective demand is *demonstrated* (perhaps by new connection payments) and ongoing payment for services is rendered (Jackson, 1998b).

In the SA context, it may be argued that ATP and benefit transfer do have some possible application. They may not be theoretically reliable approaches, but in the absence of any other form of demand assessment, they could indicate — quickly, easily and cheaply, the affordability and possible WTP of an improved supply.

4.3 Demand-responsive approach

4.3.1 DRA defined

The ‘demand-responsive approach’ (DRA) is a phrase that has been coined by the World Bank (World Bank, 1998). It is an approach to RWS that attempts to respond to consumer demands (effective demand), aimed at making projects more sustainable (than supply-driven approaches). Garn (1998) lists the following as key characteristics of DRA:

- community member make informed choices about:
 - whether to participate in the project;
 - levels of service, based on willingness to pay;
 - when and how their services are delivered; and
 - financial management and management of O&M;
- governments play a facilitative role;
- an environment enabling private (and NGO) participation is created; and
- an adequate flow of information is provided to the community.

DRA is an integrated approach to water provision. Figure 4.1 attempts to summarise how demand-responsiveness influences technical, social, financial, economic and institutional issues of water supply. Although it is the technical and financial issues that most concern this study, an integrated approach to development should always be borne in mind to improve project sustainability (Smout, 1997).

DEMAND ASSESSMENT

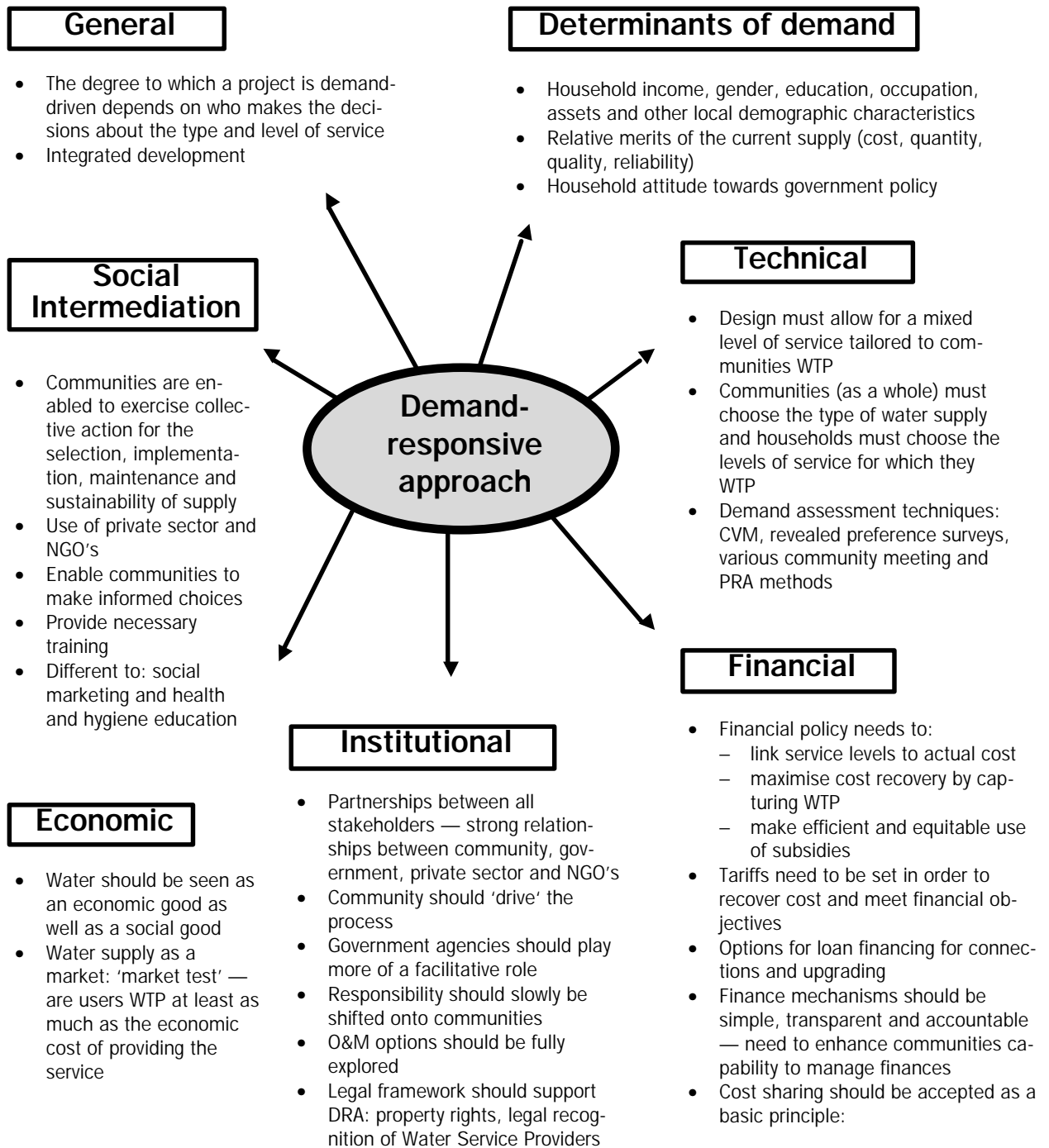


Figure 4.1. Perspectives within the demand-responsive approach

Based on a selection of papers presented at the Community Water Supply and Sanitation Conference in Washington, D.C., USA, May 1998 (World Bank, 1998)

4.3.2 DRA in project cycle

Project cycles are useful planning tools to identify the salient stages and activities within a project. The demand-responsive approach advocates that beneficiary communities are given options as to the type of supply appropriate to their needs and design should allow for levels of service to be based on individuals WTP. In order for a project to adequately respond to this demand, demand assessment needs to be central to many of the stages within the project cycle (WELL, 1998).

Figure 4.2 (on the following page) illustrates some of the activities relating to technical preparation and consultation that are necessary in order to incorporate ‘demand-responsiveness’ into the project cycle. The stages shown are those used in the World Bank project cycle (Smout, 1997).

As can be seen, demand-responsiveness requires an iterative process. Theoretically, the last two activities need to be repeated until it can be reliably established that householders are willing to pay the adjusted tariffs. Practically, this may not be possible. This emphasises the need to choose the design packages at feasibility stage as appropriately as possible. If CVM is used to assess demand, it is important that the range of technical options at feasibility caters for all WTP — this will ensure that the tariffs developed at this stage are not less than the adjusted tariffs.

Figure 4.2 proposes that demand assessment is done at feasibility stage. DFID (1998) argue that in order to clarify the financial and institutional environment at project identification or pre-feasibility stage, some form of demand assessment may be important. This will serve more as a planning tool than to inform project design. At this stage, villages may be classified into the four types proposed by the World Bank (described in 4.2.1) or some similar broad classification.

DEMAND ASSESSMENT

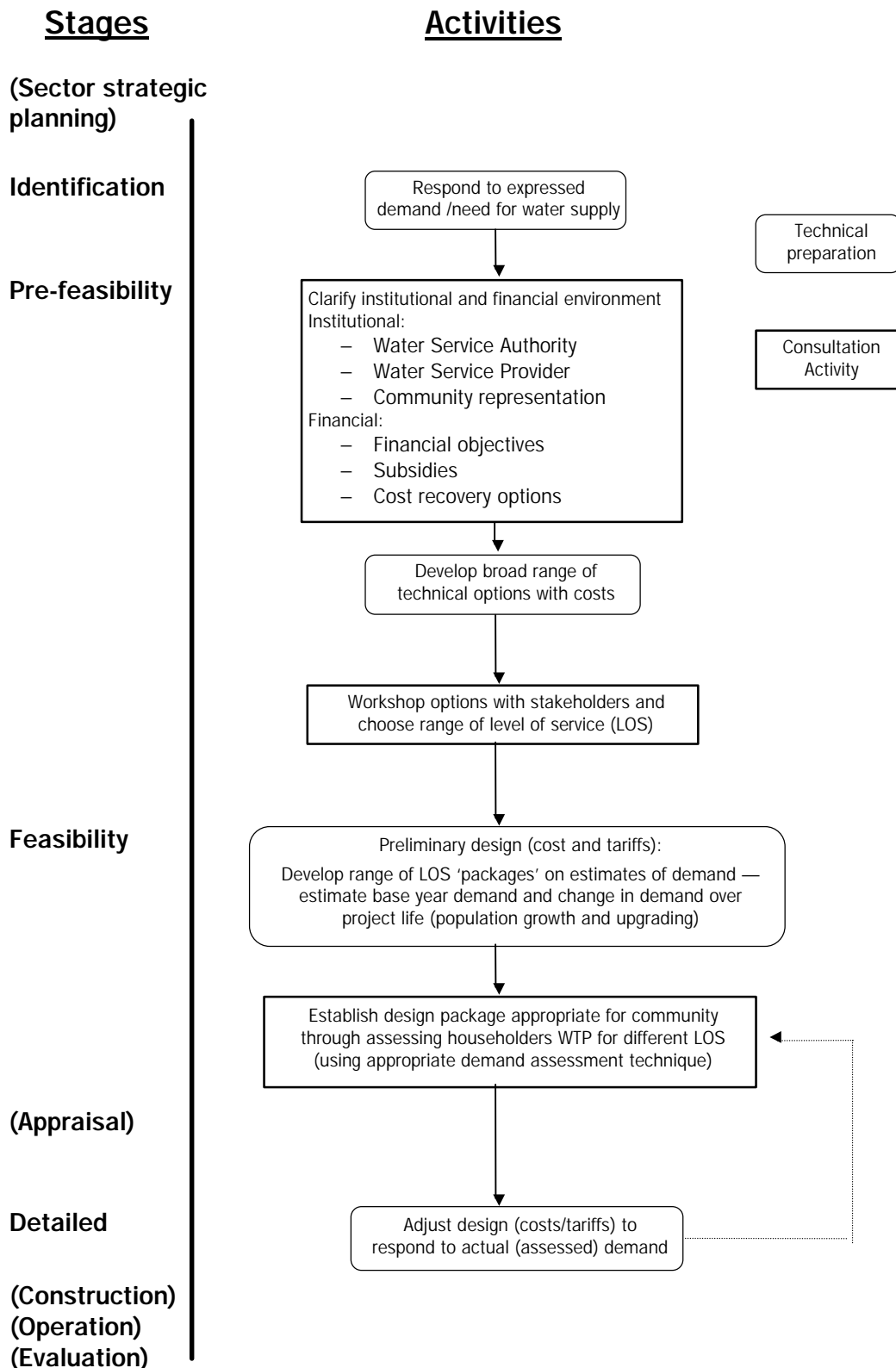


Figure 4.2. Demand-responsive project cycle

4.3.3 Concerns with DRA

Most of the ideas expressed in DRA are not new to the sector, but it is a view of RWS from a specific economic paradigm. This paradigm may not always be appropriate or applicable and the social benefits of an improved water supply should never be overlooked. This is particularly relevant to SA where government has a political responsibility to subsidise water supply to previously marginalised communities. The approach has been developed by the World Bank and may not be easily transferable to government policy. Garn (1998) comments that in order for DRA to work effectively, there needs to be more projects than funds i.e. communities need to 'compete' for funding. This may not be acceptable to government. Two other specific concerns with DRA are:

- poverty issues: DRA does not protect the poorest members of communities who may not be able to afford the service. Lifeline tariff structures can be recommended, and communities often have their own ways of looking after the vulnerable; but if water is to be managed primarily as an economic good, it is difficult to ensure that the poor are considered. The incentive (and ability) for the WSP to cross-subsidise tariffs is also questionable; and
- environmental issues: the water resource is not directly protected. It can be argued that environmental protection should be included in the tariff to charge the full economic cost of supply, but again, there may be little incentive for WSP to do this.

These and other concerns signal the need for strong regulation if DRA is to be adopted, to ensure that the social good of water is protected.

5.

Designing to Meet Demand

Rural water supply design is an iterative process involving many assumptions. Many factors influence design, some external to the project e.g. the political and institutional environment; and others specific to the project, relating to socio-economic and behavioural issues. Usually designers (particular within a supply-driven environment) use engineering conventions and standards unrelated to the specific needs (or demands) of the beneficiary community, and this can lead to inappropriate designs and unsustainable projects (see Chapter 2). This chapter attempts to highlight some of the assumptions needed for design (and the **sensitivity** of these assumptions) and proposes a methodology for designing to meet effective demand.

Chapter 4 illustrated some methods by which demand can be assessed. The accuracy of this assessment depends on the type of technique used, the reliability of the technique itself, and the skill of the practitioner. At best, findings from any of the demand assessment techniques investigated give an idea of demand *at the time of the survey*. Proponents of CVM believe that these results can reliably predict actual behaviour in the short term (e.g. ‘CV and actual behaviour’, Griffin et al, 1995), but what the designer also needs to know, is what demand will be *over the entire project life*. Many factors affect initial demand e.g. price, income, metering (see 4.1.3), and many affect the change in demand over the project life, but for the purposes of this section, four key variables are considered when designing to meet demand:

- ‘initial’ demand derived from appropriate demand assessment technique (Chapter 4);
- predicted water consumption for different levels of service (5.1.2);
- population growth (5.1.1); and
- change in level of service over the project life (upgrading) e.g. from standpipe to yard connection (5.1.1).

The methodology in this section may be useful at two stages within the project cycle: feasibility or detailed design i.e. before or after some form of demand assessment is done. The demand-responsive project cycle (Figure 4.2) illustrated the iterative nature of designing to meet demand. Realistic costs need to be estimated to inform a WTP survey, and in turn, the results of the survey will affect design. The validity of CVM should rely

on linking surveys to actual costs (Griffin, 1995), and therefore the skill of the designer in estimating these costs.

In order to show the methodology clearly, this report has applied the design principles to a specific village water supply project. The village is Seokodibeng: a typical rural village in the Northern Province of South Africa. The exercise is not really a case study — as these design options have not actually been applied — but more like a ‘worked example’ of the principles on a ‘prototype village’. However, the village does exist, and does have a piped water supply system. The need for higher LOS to be included in the project design has been expressed by many of the stakeholders in the village and in the region. The actual system will not be discussed in detail in this report, but the data used to design the existing system will be used to examine various possible technical and financial options.

If a demand-responsive approach was being followed, these options should enable the community, with the assistance of the WSP (and designer), to choose from different scenarios the most appropriate **type** of water supply system to their meet their needs. Individual households should also be enabled, by this approach, to choose the **level of service** for which they are able and willing to pay.

5.1 Technical

Some of the assumptions necessary for design will need to be informed by economists or social scientists (e.g. population growth, WTP), but many will be the decision of the engineer. Decisions may be guided by design standards e.g. peak factors, allowance for ‘unaccounted for water’; but they will also rely heavily on the discretion of the designer. Therefore, in order to make informed decisions, the designer needs to know the sensitivity of the assumptions on the outcome of the design.

5.1.1 *Mixed level of service*

5.1.1.1 *Short-term demand*

In many rural communities, and SA in particular, there is a range of income levels, and more importantly, a range of WTP for improved water supply within each community (Mvula, 1998a). Hazelton (1997) found that just over 50% of rural households live below the Household Subsistence Level, however, in most villages, there are a minority of households with incomes up to about three times this level. In order to respond to this demand, it seems most appropriate that a *mixed level of service* be offered to the community as a whole from which individual households choose their own level of service (although some researchers argue that supplying a mixed LOS may be impractical). These choices should be informed by the cost of different supply options and resultant tariffs required to meet the WSP’s financial objectives. Various supply ‘packages’ should be ‘offered’ to the community for this decision making process. This section has chosen six **scenarios** to be used as the base year demand.

Table 5.1. Levels of service for base year scenarios

<i>Scenario</i>	<i>Description</i>	<i>Reason for choosing scenario</i>
	Uniform level of service	
1	All communal standpipes (cs)	RDP 'basic level of service'
2	All yard connections (yc)	Aspirations of many communities ⁵
3	All house connections (hc)	Aspirations of many communities
	Mixed level of service	
4	80% cs, 15% yc, 5% hc	Possible outcomes of demand assessment exercise, an attempt to set 'most likely' scenarios; and can also illustrate changing level of service over time
5	50% cs, 35% yc, 15% hc	
6	20% cs, 50% yc, 30% hc	

Ideally the design packages offered to communities should include a wider range of options e.g. handpump supply. This would allow for more scatter in WTP and consequently cater for more possible demands. This report concentrates on a narrow 'band' of options for the following reasons:

- the current DWAF capital subsidy is for a relatively high level of service (equivalent to Scenario 1);
- social and political forces have resulted in (sometimes unrealistically) high expectations from communities (Mvula, 1998a); and
- it is consistent with current policy thinking in SA (Jackson, 1998b).

5.1.1.2 Long-term demand

The two most important factors affecting long-term demand are:

- population growth; and
- change in level of service or upgrading.

Population growth can be estimated based on national or local trends, although often the improved water supply itself increases population growth above the average (PDG, 1996). Upgrading is more difficult to predict. Van Schalkwyk (1996) argues that the rate of upgrading is related to economic conditions (Gross Geographic Product (GGP) — equivalent regional indicator of GNP), tariff and other 'value orientation' factors. For simplicity (and this is an assumption that designers will possibly have to make), this report has chosen to assume that upgrading (from communal standpipe to yard connection; and from yard connection to house connection) will increase by the same constant

⁵ Mvula Trust (1998a), PDG (1998), Jackson (1998a), authors' personal experience

percentage annually. Table 5.2 shows the rates used in the case study. A sensitivity analysis of these assumptions is given in Table 5.5.

Table 5.2. Change in demand

<i>Increased demand due to</i>	<i>% p.a.</i>
Population growth	2.5
Upgrading: — communal standpipe to yard connection	4
— yard connection to house connection	4

5.1.2 Water demand

The focus thus far has been on trying to assess the range of LOS for which beneficiaries are willing to pay over the project life, but more relevant to the designer is how this LOS relates to water demand. Water demand may be expressed in m³/day or average per capita consumption (l/c/d) and estimation is critical to the design of the various system components.

It is important to distinguish between water consumption (or demand, or usage) and recommended design guidelines. Consumption relates to issues such as behaviour, education, queuing time at water points and discharge from taps and others. The link between consumption and the time required for water collection has been clearly shown by many researchers. The time for water collection can be seen to relate to the level of service of the supply, i.e. a lower level of service (e.g. a source some distance from the house) will require a greater collection time than a higher level of service (e.g. a standpipe within the homestead). Design guidelines, on the other hand, are influenced by consumption patterns, but also consider engineering standards, safety factors (e.g. peak factors to allow for uneven daily use) and conservative averages.

Domestic water is required for drinking, cooking, cleaning, dish washing, clothes washing, personal hygiene, sanitation, gardening and other 'leisure' uses. Van Schalkwyk (1996) found that domestic water use relates to a 'level of living index'. This index relates population, income, education, dwelling construction, agricultural activity and household size. Van Schalkwyk found that water requirements for domestic activities ('basic needs' water) were similar for different levels of living, but significant increases were found for higher levels of living where water was used for washing, gardening, sanitation and other uses.

Consumption patterns will differ from country to county and area to area (particularly urban to rural) as water uses differ (Hofkes et al, 1981). This is particularly true for individual connectors who have a wider variety of demands depending on water uses (and seasons) e.g. gardening and stock watering practices. There are significant discrepancies in the literature (see Table 5.3) as to what domestic consumption could be expected from different service levels and therefore discretion will need to be used in

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design. The distinction between actual usage and recommended design figures is often also not clear.

Table 5.3. Domestic water demand vs. level of service

<i>Level of service</i>	<i>Water consumption (l/c/d)</i>					
	Cairncross and Feachem, 1993 ⁶	Hofkes et al, 1981 ⁷	Jinja, Uganda ⁸	PDG, 1996	Van Schalkwyk, 1996	This report
Communal standpipe:						
> 200m walking distance	< 16			15	25	
< 200m walking distance	16	30	15.5	30	35	25
Yard connection	> 16	40	50	70	80	80
House connection:						
— single tap		50	155	120	130	130
— multiple taps		150			250	

The figures used in this report are for design purposes, i.e. they do not necessarily assume these to be actual consumption levels, but reasonable estimates to use for design. Other reasons these figures have been chosen are:

- 25 l/c/d to within 200m is the supply level defined by DWAF as a ‘basic level of service’;
- 80 and 130 l/c/d are figures established by van Schalkwyk in an extensive study near to where Seokodibeng village is situated;
- these figures are close to those used by PDG — a comparison of the case study and similar studies undertaken for the PDG report (PDG, 1996) is made in 5.3; and
- they are conservative estimates.

A study of water consumption in the Sudan (Cairncross and Kinnear, 1988) showed an inverse relation between per capita consumption and household size. It also showed some differences between ‘observed’ consumption levels (observers standing outside of homesteads) and ‘stated’ consumption levels (determined by household questionnaires). There are many other demands (apart from domestic) for water in rural areas, in particular agriculture and stock watering. This report considers two other water demands:

⁶ These figures are derived from a graph plotting time for water collection against quantity collected. The graph shows 16 l/c/d consumption for a collection time of between 4 and 30 minutes.

⁷ These are typical values within given ranges.

⁸ Quoted in WELL, 1998. No distance from standpipe is given.

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- (i) *institutional demand*: this will vary significantly from area to area. In Seokodibeng it is catering for the demands of the schools, churches and community centre and is estimated at 15% of the domestic demand (consistent with PDG, 1996)
- (ii) *unaccounted for water (UAW)*: is assumed to be mainly from unauthorised connections and leakage. Water utilities around the world quote a range of figures for UAW (from 4.5% in Germany to 67% in Turkey) — this is due to vastly different conditions, but also different classifications of what constitutes UAW (Olukayode, 1998). DWAF has stipulated for urban supplies in SA that UAW may be no more than 10% of total demand for schemes it is prepared to subsidise. However, after a study conducted by Palmer and Eberhard (1994) of UAW in municipalities in SA, they recommended that design should cater for 15% UAW in well managed areas and 25% in poorly managed areas. In this report UAW is assumed to be 20% as a very rough estimate (figure recommended by Olukayode, 1998).

The water demand assumed for the base year for the six scenarios is shown in Table 5.4.

Table 5.4. Average water demand for base year

Scenario	<i>Domestic</i>	<i>Institutions</i>	<i>UAW</i>	<i>Total (average equivalent)</i>	
	l/c/d	15%	20%	l/c/d	m ³ /day
1	25	4	6	35	66
2	80	12	18	110	206
3	130	20	30	179	335
4	39	6	9	53	99
5	60	9	14	83	155
6	84	13	19	116	217

See **Appendix 5.1** for further calculations

Table 5.5 shows the water demand as it changes over the project life (year 1, 10 and 20 have been chosen to illustrate the change) for a ‘most likely’ scenario (base year LOS are the same as Scenario 4). It also shows the sensitivity of demand to population growth and increase in LOS (upgrading). Total demand is the sum of domestic (communal standpipe and individual connections), institutional and UAW in m³/d; this is averaged into an equivalent per capita demand in l/c/d.

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Table 5.5. Total water demand over project life

	Year 1			Year 10			Year 20		
	Houses	m ³ /d	l/c/d	Houses	m ³ /d	l/c/d	Houses	m ³ /d	l/c/d
Population growth (using a constant rate of 4% annual increase in individual connections)									
2.5% ⁹	312	99	53	390	143	61	499	221	74
1% ¹⁰	ditto			341	125	61	377	167	74
6% ¹¹	ditto			527	193	61	944	418	74
Increase in individual connections (upgrading) at a constant population growth ¹²									
4%	312	99	53	390	143	61	499	221	74
0%	ditto			390	124	53	499	159	53
8.8% ¹³	ditto			390	174	74	499	380	127

See **Appendix 5.2** for calculations

5.1.3 Design criteria

5.1.3.1 Design standards

The design standards used for this design are based on the ‘RDP Water Supply Design Criteria Guidelines’ (DWAF, 1997b). Some salient design criteria are:

- population growth: 2.5%;
- household size: six persons;
- designs are for 24 hour flow at full pressure;
- design principles based on acceptable practice as recommended by the Engineering Council of SA (ECSA) and the CSIR ‘Green book’ — these are contained within DWAF, 1997b; and
- labour-intensive construction practices.

5.1.3.2 Peak factors

Peak factors are used to allow for the daily and seasonal distribution of water use — this is influenced by the usage habits of consumers. Van Schalkwyk (1996) found two significant *daily peaks*: one between 6h00 and 10h00 and the other between 16h00 and 18h00. *Seasonal peaks* are affected mainly by gardening activities (more water is used

⁹ Average figure used in PDG (1996) report

¹⁰ National average in 1995 (CDE, 1995)

¹¹ Highest estimate made in the area (PDG, 1996)

¹² Upgrading from communal standpipe to yard connection; and yard connection to house connection is assumed to be at the same rate. Population growth is at 2.5%.

¹³ 8.8% chosen to give all individual connections i.e. 25% house and 75% yard connections at year 20

in the planting season etc.), and consequently are higher for users with individual connections. There are many factors affecting these peaks, the most significant being:

- population size: larger populations ‘smooth out’ distribution reducing daily peak factors;
- level of service; and
- type of technology: local or household storage (distributed storage) can be used to ‘flatten’ out peaks therefore reducing the size (diameter) of distribution piping.

Different guidelines recommend significantly different peak factors: the literature revealed a range from 2 (in the Philippines) to 5.5 (CPA ‘Brown book’) (Palmer and Eberhard, 1994). The two peak factors used in this report (based on van Schalkwyk, 1996 and recommended by DWAF, 1997b) are shown in Table 5.6. The daily and seasonal peaks even each other out to a total distribution peak.

Table 5.6. Peak factors

	<i>Daily peak</i>	<i>Seasonal peak</i>	<i>Total distribution peak</i>
Communal standpipe	3	1.2	3.6
Yard connection	2.6	1.35	3.5
House connection	2.4	1.5	3.6

5.1.3.3 Design parameters

Design parameters used for the sizing of the different components of the system are as follows:

- a) *Source*: Average Annual Daily Demand (AADD i.e. the daily demand (m³/day) averaged over the year) based on present population abstracting less than the safe yield of the borehole for an 8 hour pumping day;
- b) *Pumping main*: AADD of present population;
- c) *Storage*: AADD (present population) for 48hr storage;
- d) *Distribution*: AADD (20 year design horizon) at peak flow; and
- e) *Standpipes*: Maximum cartage — 200m from every resident, minimum standpipe yield at 0.17 l/s, minimum residual head at standpipe of 10m.

See **Appendix 5.1** for water demand of each component.

5.1.3.4 Technology choice

The choice of technology will have a big impact on the cost and the extent to which the community can be involved in construction and O&M. Developments in ‘appropriate technologies’ and technologies that enable ‘village level operation and maintenance’ (VLOM) should be considered. There is a strong argument for using ferrocement for the storage reservoir and HDPE piping for distribution. Distributed storage and ‘trickle-feed’ systems can be useful to reduce bulk storage and piping costs. Community participation in construction can be a key factor in creating a ‘sense of ownership’ of the project, and thereby improving payment of water charges (Evans and Appleton, 1993).

5.1.4 Seokodibeng water supply

Seokodibeng is a Pedi village within Sekhukhuneland, in the Northern Province of South Africa. In 1994 the village consisted of 283 homesteads (approx. 1,700 people), a primary school and three churches. In the past, villagers relied on water from a surface water source many kilometres from the village, until in 1994 a piped water supply scheme was constructed with funds from The Mvula Trust. Today, the scheme is managed by the Seokodibeng Water Committee and relies on payment from residents and DWAF to finance the recurrent costs.

The system was designed to meet the RDP basic level of service (i.e. communal stand-pipe supply), but householders want a higher level of service. A recurring request from many community members is for yard and house connections, but the Water Committee are worried that individual connections will cripple the system. It is doubtful whether residents will continue to pay for diesel (to run the pumps) if there is no mechanism to enable them to upgrade. Data from Seokodibeng is used as a case study to investigate the implications of designing to meet this expressed demand. Map 1 shows the location of Seokodibeng village. It is 400km northeast of Johannesburg and 100km southeast of the Northern Province capital of Pietersburg.

Map 5.1. Location map of Seokodibeng



The design has been based on data collected for the original design done in 1994 (CSIR, 1994) and from subsequent data collection. The following key assumptions are made in the designs of the six scenarios:

(i) *source:*

- Seokodibeng is reliant on groundwater (the nearest surface water sources are over 15km away). There are no significant springs or wells in the area. There are two strong (for the area) boreholes with safe yields of 8.3 and 7.5 l/s. Only in Scenario 3 was the second borehole necessary, as all the other source requirements were less than 8.3l/s;
- boreholes are designed to be equipped with positive displacement pumps and diesel engines (no electricity is available). All borehole siting, drilling, testing, design and equipping has been estimated from experience in the area;
- water quality is assumed to be adequate (the fluoride content is between 1.5 and 2 mg/l, but it has been assumed that no treatment would be appropriate;

(ii) *storage:*

- reinforced concrete reservoirs have been specified;
- there is a strong argument for ferrocement, but as yet DWAF do not accept this technology in their guidelines;

(iii) *distribution:*

- the pipe network has been designed using BRANCH software (Modak and Dhoondia, 1991) using uPVC piping (see *Appendix 5.3* for an example of one of these designs — Scenario 1);
- Scenario 1 was designed for the peak flow to meet the minimum standpipe yield, the other 5 had higher demands;

(iv) *connections:*

- communal standpipes are shown on Figure 5.1. Taps at standpipes are designed to fill a 20l bucket in two minutes and serve an average of 10 families each (this is low, but necessary to meet the minimum cartage criteria of 200m). For node and pipe details see *Appendix 5.3*;
- individual connections are assumed to be from the distribution mains. All connections are metered and have on-site drainage;
- yard connections are standpipes at the boundary of the yard;
- house connections are single taps in the kitchen with a basin fitted;
- the cost of the three types of connections (piping from mains, connection, meter, drainage, labour) is shown in *Appendix 5.4*.

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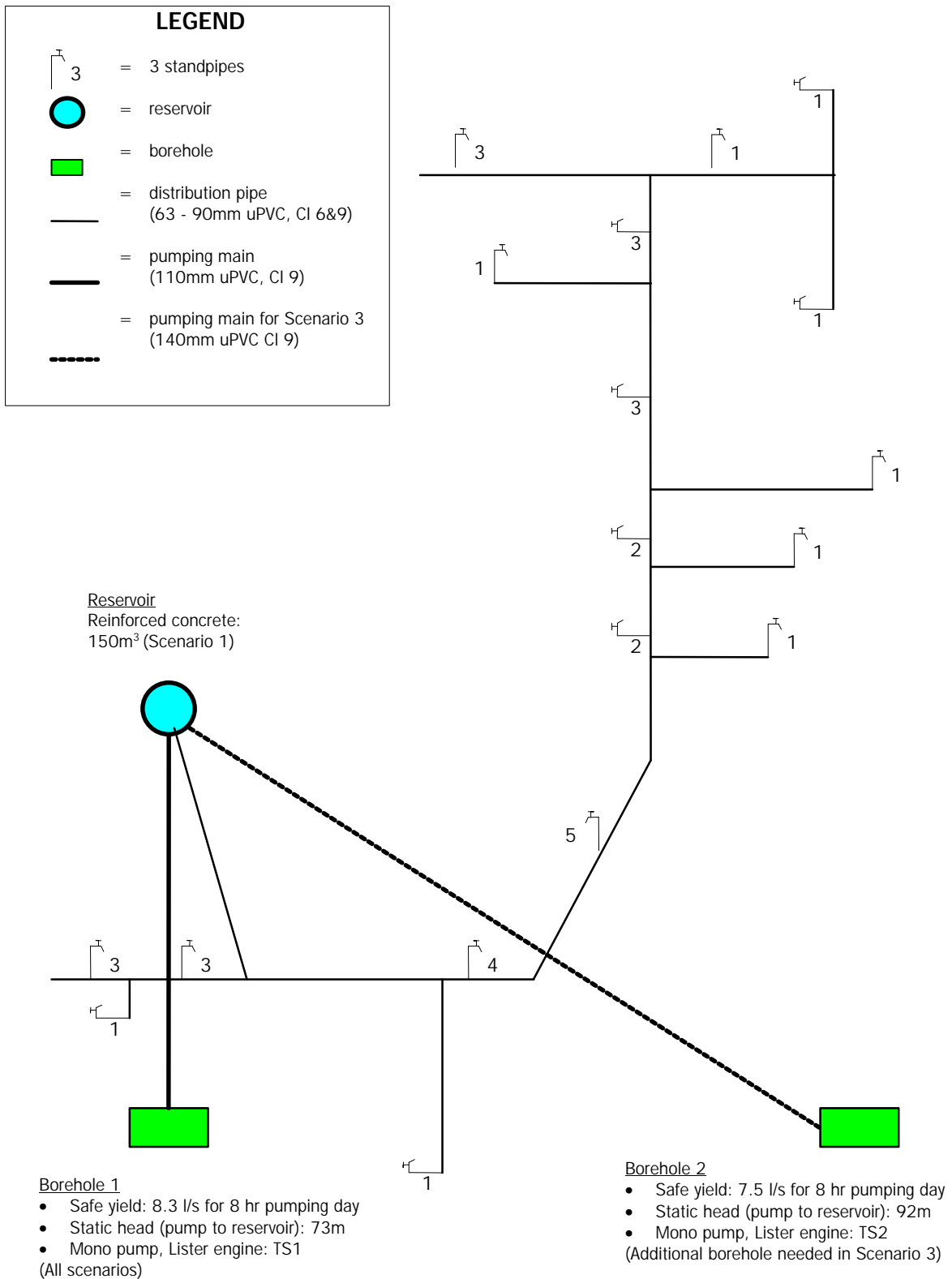


Figure 5.1. Schematic layout for Scenario 1

5.2 Financial

The financial issues considered in this section are ultimately concerned with assessing financial viability. The six scenarios illustrate the difference in capital and recurrent costs, and the resultant tariffs that would need to be charged in order to reach different financial objectives of the WSP. Cash flows and subsidy issues are also considered.

All costs (material, labour, plant and professional) are local and all prices are in South African Rands (R), based on local rates for May 1998 (inclusive of VAT, transport etc.). Costs were obtained from a number of sources — see ‘Sources of cost data’ in *Appendix 5.4*. Exchange rate in May 1998:

1\$ (US) = R 5.00; and

1£ (UK) = R 8.30.

5.2.1 Capital costs

Capital costs have been divided into the four main components used in the design. The following assumptions have been made:

- Borehole siting, drilling, testing and equipping: hydrogeological assumptions have been made from previous drilling experience in the area and from information gathered from the existing boreholes;
- Reservoir: an average rate (R/m³) for construction of reinforced concrete reservoirs on Mvula Trust projects in the area has been used;
- Professional: percentage-fee for technical work (based on DWAF, 1997b and Vinenings, 1998) and lump sums for social, training and committee costs;
- Labour rates are chosen for task work for a estimated minimum daily wage of R30 (an assumed excavation rate at 2m³ per day was used for trenching); and
- Individual connection costs are included in the recurrent costs, communal standpipes are within the capital costs.

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Table 5.7. Capital costs

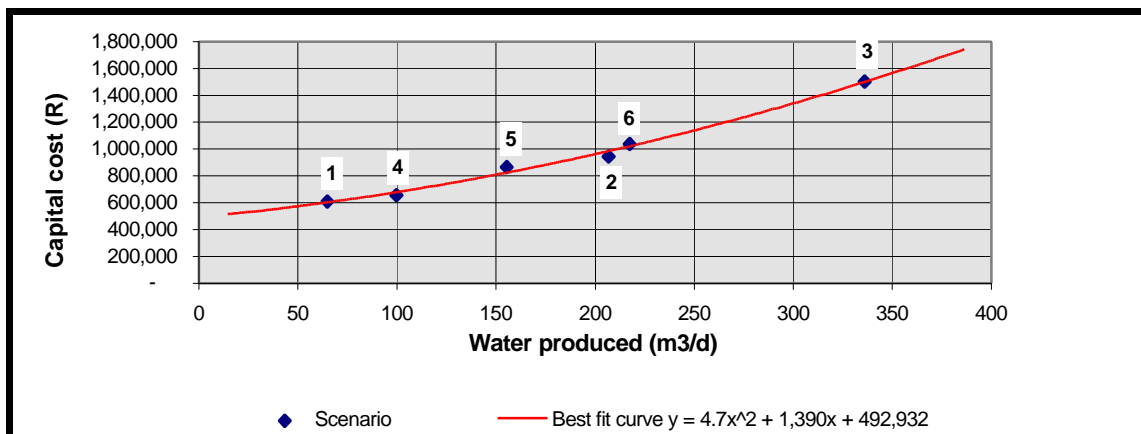
Scenario	Water produced (m ³ /day)	Source development	Storage	Distribution	Professional	Total	R/ capita	Ratio
1	65	100,370	111,900	259,858	135,678	607,807	324	1
2	207	150,154	335,700	298,828	157,854	942,538	503	1.6
3	336	351,227	522,200	414,127	215,181	1,502,738	802	2.5
4	100	117,948	149,200	260,536	128,556	656,244	350	1.1
5	155	137,614	261,100	317,346	150,031	866,096	462	1.4
6	217	162,805	335,700	369,545	167,358	1,035,414	553	1.7
Average %		18	29	36	18	100	499	

See **Appendix 5.5** to see detailed calculations of capital costs of all scenarios

Table 5.7 shows the capital investment needed to construct water supply systems to meet the base year water demands of the different scenarios (expressed by water produced by the system in m³/day — the difference between water produced and water consumed, in this case, is the component termed unaccounted for water).

Graph 5.1 plots the total capital cost against the potential daily water production. A summary of total costs and water production is shown in **Appendix 5.6**. Per capita capital cost are shown in Table 5.7 in order to inform possible subsidy decisions.

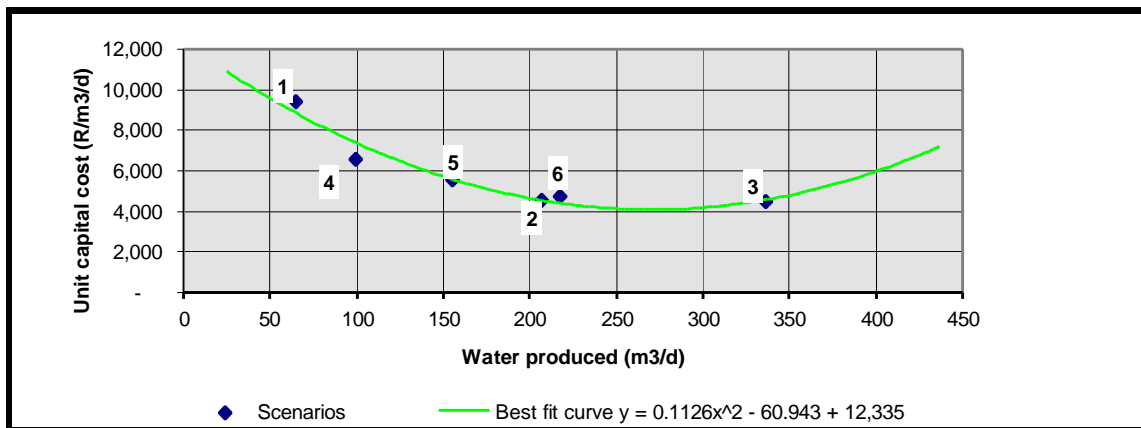
Graph 5.1. Capital costs



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The capital costs shown in Table 5.7 are for different scenarios at the base year. Water demand will change over the project life due mainly to population growth and upgrading (as projected in Table 5.5). The capital investment needed to meet these changes in demand can be approximated by the best-fit curve in Graph 5.1 (note: this is a quadratic). This is a useful relationship in order to calculate the future capital costs needed to respond to future (increased) demands. In practice, capital investment would be ‘lumpy’ i.e. capital investments would take place as demand grew in stages. Investment decisions would need to be based on predicted growth in demand, design considerations, cost recovery options and subsidies. Different project components may need to be considered separately e.g. distribution (pipes) should cater for water demand at the end of the project life, whereas source and storage could be upgraded when necessary. Graph 5.2 shows the average capital costs of the six scenarios and the best-fit curve approximating the unit average capital cost.

Graph 5.2. Average capital costs



Economists often use polynomials to approximate cost curves (Merrett, 1997), or various ‘U-shaped’ curves (Cotton et al, 1991). In this case, a quadratic has been used for the following reasons:

- it satisfies a ‘best fit’ curve for the points;
- cost of supply decreases as demand increases in the beginning of the curve — this illustrates an economy of scale which is consistent with theoretical predictions (Merrett, 1997); and
- if demand is greater than 270 m³/day, the average capital cost of water will increase with increased production i.e. there will be a diseconomy of scale. Practically this is due to new sources being required to meet this demand, and the simplest and cheapest sources will always be exploited first (Franceys, 1994). The curve approximates this predicted investment (which would practically be represented by a stepped line).

5.2.2 Recurrent costs

Recurrent costs in this study are considered to be all costs incurred over the project life other than capital costs. Five categories of recurrent costs have been calculated:

- (i) *connection costs*: it is assumed that households will pay the full cost of individual connections: half of the amount ‘up-front’ (before the connection is made) and the balance with loans at 15% (excluding interest) over 5 years (assumption made by PDG, 1996). It is envisaged that these loans will be available from a micro-financing loan facility. Communal standpipes are included in the capital costs. The cost of the standpipe is high — this is due to the nature of the design (CSIR, 1994). It is a sturdy structure with good drainage, constructed to be a symbol of the efforts made by the community;

Table 5.8. Cost of connections

	Total cost (R)	Up-front payment (R)	Monthly payment over 5 yrs (R/month)
Communal standpipe	1,035	—	—
Yard connection	942	471	12
House connection	1,242	621	15

See **Appendix 5.4** for detailed calculations

- (ii) *staffing, administration and capacity building*: this will depend greatly on the WSP. Costs have been estimated for a community-based water committee based on costs incurred in similar projects. These salaries have been paid on other projects, but it must be noted that they are beneath the minimum wage as recommended by COSATU (Congress of SA Trade Unions). These arrangements will need to be negotiated and appropriate capacity built. The salary of committee members and pump operators is set at R750/month, maintenance staff and water bailiffs at R400/month and labourers at R30/day (during construction);
- (iii) *operation costs*: the primary cost is fuel for pumping (this is calculated as a function of flow, from known costs in similar projects), other costs are calculated on a percentage basis;
- (iv) *routine maintenance and repair*: flat rate figures have been estimated from experience; and
- (v) *depreciation* is an accounting book entry to be seen in this context as a replacement fund. The economic life of the different components have been set at: source (pumps, engines, pump house etc.) — 10 years, pipework and reservoir — 30 years and standpipes at 20 years. The discount factor has been set at 8% (this is consistent with DWAF, 1997b design guidelines)

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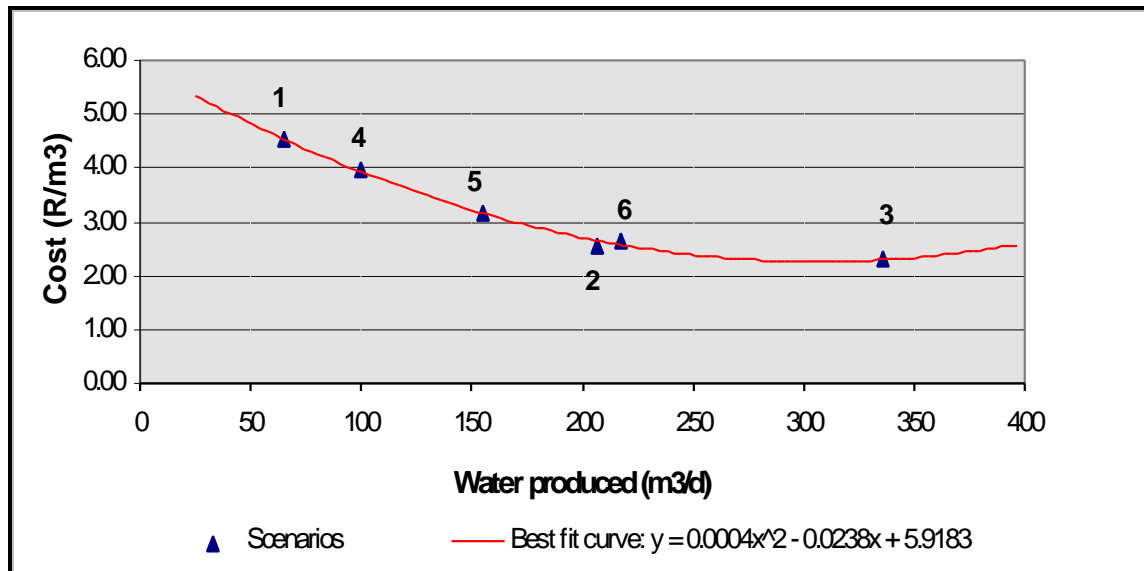
Table 5.9. Recurrent costs

Scenario	Water produced	O&M			O&M + depreciation		
		m ³ /day	R/mon	R/mon/house	R/m ³	R/mon	R/mon/house
1	65	5,046	16	2.56	8,906	29	4.52
2	207	9,885	32	1.57	16,168	52	2.57
3	336	13,161	42	1.29	23,500	75	2.30
4	100	7,645	24	2.52	12,004	38	3.96
5	155	9,127	29	1.93	14,881	48	3.15
6	217	10,958	34	1.60	17,539	56	2.65
Average				1.91			3.19

See Appendix 5.5 for detailed calculations

It is interesting to note that although the actual cost per house (based on predicted consumption) increases as the level of service increases, the unit cost per quantity produced decreases. Graph 5.3 shows the unit recurrent costs of the 6 scenarios, and the best fit curve extrapolating this function. The initial economy of scale, and subsequent diseconomy of scale can be seen.

Graph 5.3. Recurrent costs (O&M + depreciation)



5.2.3 Tariffs

Section 3.3.4 described some of the complexities of tariff setting. The tariffs considered in this section have made the following assumptions:

- the WSP provider is a public institution: either a village water committee or local government authority i.e. financial objectives would stress social equity issues rather than profit maximising;
- cross-subsidy between consumers is politically, socially and economically desirable;
- loan finance is available for individual connections and bulk infrastructure for the WSP; and
- discount rate is assumed at 8%.

In order to illustrate some of the methods by which tariffs can be set, three models are considered:

- (i) static tariff model: considers tariffs for a single year;
- (ii) dynamic tariff model: considers tariffs over the project life; and
- (iii) recommended tariffs: this is effectively a mixed tariff model, combining aspects of both models, flat and metered connection rates and other realistic assumptions.

5.2.3.1 Static tariff model

The static tariff model considers tariffs for the six scenarios, for the base year, using different cost recovery options.

Table 5.10. Static tariff model

<i>Tariffs based on recovery of:</i>	<i>Tariffs for different scenarios (R/m³)</i>					
	1	2	3	4	5	6
O&M costs (ignoring UAW)	2.56	1.57	1.29	2.52	1.93	1.60
O&M costs (consumers pay for UAW)	3.08	1.88	1.54	3.03	2.32	1.92
O&M + depreciation costs	5.43	3.08	2.96	4.75	3.78	3.18

Note:

- Tariffs set to recover just the O&M costs are the same as the costs in Table 5.9;
- It is not sensible to calculate the base year tariff to recover any capital costs, as these will not need to be recovered in total (if at all) in the first year. The dynamic tariff model illustrates the impact of capital costs;
- The assumed financial objective of the WSP is to break-even (i.e. revenue = cost);
- All consumers (i.e. all domestic users — with different LOS — and institutional users) are charged equal rates; although it is impractical to charge standpipe users a rate based on consumption unless there is some control over the use of the standpipe;

- Tariffs decrease as the level of service increases (although actual monthly bills should be higher due to higher consumption) due to the economies of scale of the costs; and
- Charging for UAW is a controversial issue (Olukayode, 1998): it is necessary for the WSP to recover these costs, but there also needs to be a clear incentive for the WSP to minimise UAW, therefore UAW needs to be regulated to ensure efficiency.

5.2.3.2 *Dynamic tariff model*

The dynamic model considers tariffs over the project life. Calculations are based on the ‘most likely scenario’ as described in 5.1.2. Water demand is as calculated in Table 5.5 for a base year level of service equivalent to Scenario 4 and subsequent population growth (2.5%) and upgrading (4% p.a.) as shown. AIC calculations for base year demands equivalent to Scenario 5 and 6 are shown in *Appendix 5.8*. Table 5.11 shows tariffs at the beginning, middle and end of the project.

Table 5.11. Dynamic tariff model

<i>Tariffs based on:</i>	<i>Tariffs in different years (R/m³)</i>		
	Year 1	Year 10	Year 20
Break-even annually to recover:			
O&M	2.73 ¹⁴	2.33	1.84
O&M + depreciation	4.58	3.80	2.84
O&M + depreciation + difference in capital cost	6.91 ¹⁵	4.16	3.34
O&M + depreciation + full capital cost (incl. interest) ¹⁶	9.77	6.15	4.63
Marginal costing (using Average Incremental Costs)			
O&M	2.35	2.35	2.35
O&M + depreciation	3.84	3.84	3.84
O&M + depreciation + difference in capital cost	4.35	4.35	4.35
O&M + depreciation + full capital cost (0% interest)	5.73	5.73	5.73
O&M + depreciation + full capital cost (13% interest)	6.44	6.44	6.44

See *Appendix 5.7* for example of break-even tariff calculations;

See *Appendix 5.8* for Average Incremental Cost calculations

¹⁴ The costs in year 1 for this scenario should be the same as Scenario 4 in the base year i.e. R3.03 (see Table 5.10), however, the best fit curve of the O&M cost approximates this cost, resulting in it being slightly lower.

¹⁵ The tariff in year 1 is significantly higher than year 2 due to the difference in capital cost between this scenario and Scenario 1 being payable in the first year.

¹⁶ The capital cost has been treated as a principle loan, payable over 20 years at 13% interest (13% has been used for consistency with PDG, 1996 — it excludes inflation)

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Note:

- All types of consumers are charged the same rate (R/m³);
- Cost of UAW is charged to the consumer; and
- All tariffs decrease as demand increases over time — this is consistent with the economy of scale shown in the recurrent cost curve.

5.2.3.3 Recommended tariffs

The recommended tariff structure is based on the following reasons and assumptions:

- a capital subsidy based on the RDP ‘basic level of service’;
- the difference in capital cost between the subsidy and the actual cost is financed by the project: this is approximated by the best fit curve for the annual incremental cost AIC) (see *Appendix 5.8*);
- cross subsidy between higher and lesser consumers; and institutional and domestic consumers i.e. institutions pay > individual connectors pay > communal standpipes per quantity of water consumed (R/m³);
- communal standpipe users are charged a *flat rate* based on the O&M costs of an RDP level of service;
- individual connections (yard and house) tariff based on AIC of O&M plus depreciation plus the difference in capital cost between the scenario and the capital subsidy. The connection cost over the first 5 years is included in this figure. (*metered rate*); and
- institutional tariff based on AIC of O&M + depreciation + full capital cost (including interest) (*metered rate*).

Table 5.12. Recommended mixed tariffs

Level of service	Typical consumption	Tariff		Connection cost (first 5 years)		Total
		R/m ³	R/mon	R (up-front)	R/mon	
	m ³ /mon/house	R/m ³	R/mon	R (up-front)	R/mon	R/mon/house
Communal standpipe	4.6	(3.50)	16	—	—	16
Yard connection	14.6	4.35	64	471	12	76
House connection	23.7	4.35	103	621	15	118
Institutions		6.44				

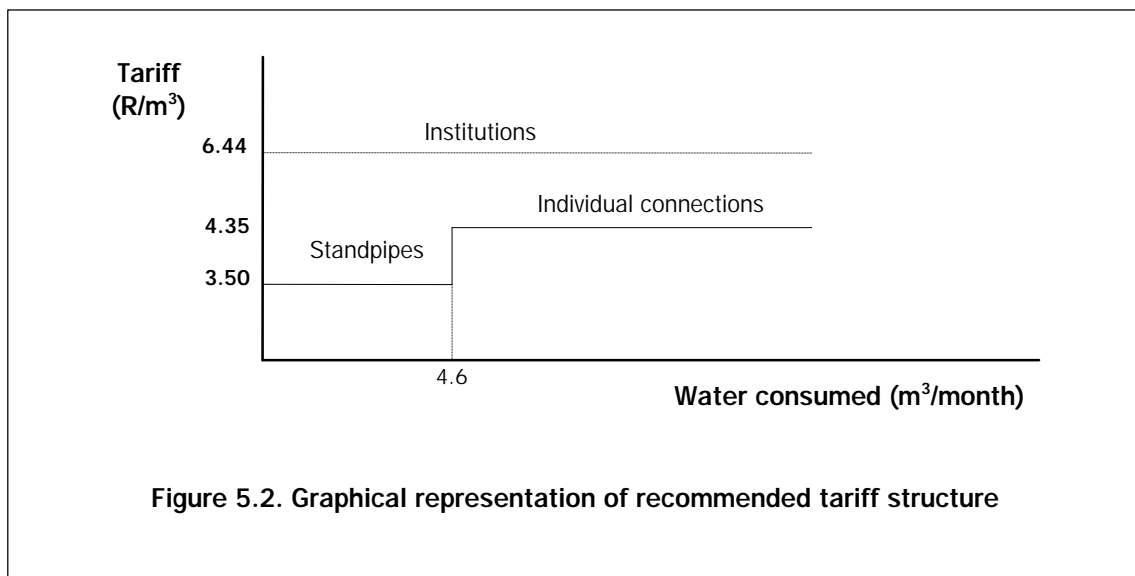
Comments on recommended tariffs

Section 3.3.4 showed that decisions over tariffs will be affected by many factors other than just financial issues. The WSP needs to be responsive to consumers in order for tariffs to fully capture WTP. The WSP needs to set a clear tariffing policy and market forces will dictate price.

Tariffs in Table 5.12 are for a specific village and use particular assumptions. A sensitivity analysis was not done for all of the assumptions, but Table 5.5 illustrated the impact on water demand on two key factors. Although it is difficult to generalise the findings from this case study, the following should be noted:

- it would be sensible to compare these tariffs to some measure of ATP. If we consider the average disposable income for the province as used on Graph 4.1, R16 /house/month would represent 3% of the average household income. This may not give any reliable indication of WTP, but it does inform the designer as to the relative value of the tariff;
- the tariffs seem high when considering typical rural expenditure in the area. A WTP survey in three villages in the Northern Province (Mvula, 1998c) found that households in each of the villages were willing to pay R22, R46 and R54 per month respectively for water (it is unclear if these were tested against different LOS);
- costs enjoyed substantial economies of scale, thus the greater the demand — from increased consumers and levels of service — the cheaper water can be produced;
- as individual connections are generally believed to have high price elasticity of demand (e.g. Hazelton, 1997), it is likely that consumption would drop significantly if tariffs were high. This would reduce monthly bills substantially.

Figure 5.2 shows a graphical representation of the tariff structure. Note the standpipe tariff would be set at some ‘lifeline’ value related to affordability for the poorest households.



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Comparison with other scenarios

The dynamic and recommended tariffs modelled assumptions based on an initial water demand equivalent to scenario 4. Table 5.13 shows the change in the AIC for the different mixed levels of service, i.e. Scenario 4, 5 and 6.

Table 5.13. AIC for different scenarios

<i>Tariffs to recover:</i>	<i>AIC (R/m³)</i>		
	4	5	6
O&M	2.35	1.87	2.04
O&M + depreciation	3.84	2.90	3.28
O&M + deprec. + difference in capital cost	4.35	3.77	4.47
O&M + deprec. + full capital redemption (at 13%)	6.44	5.01	5.32

See **Appendix 5.8** for calculations

Note:

- A consistent economy of scale prevails;
- Tariffs are similar for the different base level scenarios. This means that the sensitivity of the tariff to base year demand assessment is not significant. If the WSP sets tariffs based on Scenario 4 and the actual demand was closer to Scenario 6, the tariffs are actually higher than is needed for financial viability. This is a significant finding.

5.2.4 Cash flow

The reason for considering cash flow in the design is twofold:

- (i) to show the effects of different tariff structures on financial viability as indicated by net present value (NPV) and financial internal rate of return (FIRR); and
- (ii) to investigate the need for financing negative net revenue over the project life.

These issues would be particularly pertinent if responsibility for water provision is devolved to a community level or to the private sector. The following observations should be noted:

- break-even tariffs will obviously yield zero net revenue;
- tariffs set on AIC will show a zero net present value when revenue is set against the appropriate costs. This implies that the FIRR is equal to the opportunity cost of capital (measured by the discount factor). If the project has a target FIRR higher than this discount factor, tariffs will need to be set higher than the AIC; and
- mixed tariff structures will differ depending on the tariff policy that is adopted. Table 5.14 illustrates some implications of different tariffs options based on a mixed tariff structure. Financial indicators that have been used are:

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- ‘Loan finance’: this indicates the maximum cumulative negative net revenue over the project life that needs to be financed;
- NPV sums the predicted cash stream (net revenue) over the project life based on estimated discounts rates (8% is used for consistency with PDG, 1996). Positive values indicate positive net revenue and therefore financial viability;
- FIRR is useful to compare project cash flows with the opportunity cost of capital. If $FIRR > \text{discount factor}$ (8% in this case), the project can be assumed to be financially viable.

Three options have been chosen to represent different scenarios for the following reasons:

Option 1: — based on recommended tariffs as in Table 5.12;

Option 2: — standpipe tariff set to a ‘commonly used figure’ for O&M costs (this figure has been used as a rule-of-thumb for village water tariffs on some projects);

- metered consumers set at the same rate (for practical reasons);
- metered rates set to produce zero NPV and consequently $FIRR = DF$;

Option 3: — standpipes fully subsidised by other consumers — this may be a useful assumption faced with zero payment levels for public services;

- institutions pay double the rate of individual connectors; and
- rate for metered connections set to result in zero NPV.

Table 5.14. Loan finance, NPV and FIRR

	<i>Unit</i>	<i>Option 1</i>	<i>Option 2</i>	<i>Option 3</i>
Tariff				
standpipe	R	16	5	0
Individual connections	R/m ³	4.35	6.16	5.63
institutions	R/m ³	6.44	6.16	11.26
Loan required	R	145,990	204,127	212,424
NPV	R	-6,873	0	0
FIRR	%	7.6	8.0	8.0

See **Appendix 5.9** to see calculations for options 1,2 and 3

Average monthly bills for yard and house connections would be R90 and R146 for option 2 and R82 and R133 for option 3 respectively (excluding connection costs).

In all of these options, the project cash flow incurs negative net revenue until year 8. This implies that the WSP will need to access loan finance from some source. If commercial lending agencies were not prepared to finance this risk, would the cash burden then fall onto the Water Service Authority or national government?

Consideration also needs to be taken as to the financing of individual connections. This report has assumed that micro-financing institutions would be in existence and prepared to offer this type of loan. Research is currently underway investigating this issue ('Help Manual for Rural Water Credit' — Mvula, 1998c).

Section 3.1.3 described the methods used to assess economic viability. True economic analysis or estimation of consumer surplus is not possible in this case study as no information is available the situation before and after the proposed design. Economic analysis would need to rely on using the FIRR as project viability.

5.3 Comparison with other studies

It is generally agreed (e.g. PDG, 1998) that there is a substantial range of costs between RWS projects. Many factors influence cost and tariffs and this makes it difficult to compare the findings of this report with other figures in the literature, however, it does seem of value to place these findings within some context. The following studies are considered to this aim.

5.3.1 Africa

5.3.1.1 IDWSSD

The World Bank estimated the average tariff charged by African water utilities in 1990 to be \$0.25/m³, although the suspected actual cost of supply (calculated from the AIC) was \$0.75/m³ (Franceys, 1998). Table 5.15 is taken from findings of the IDWSSD. It is interesting to see the vast range of costs.

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Table 5.15. Cost of water supply in Africa (1990)

Country	Capital cost			Operating cost
	Urban	Rural		
	Standpipe	House connection	(doesn't specify)	
	US\$/capita	US\$/capita	US\$/capita	US\$/m ³
Angola	50	120	30	0.45
Benin	25	130	—	0.55
Botswana	55	91	196	0.75
Central African Republic	320	150	150	
Nigeria	11	22	5	0.02
Sierra Leone	55	100	30	N/A
Uganda	300	500	60	N/A
Zaire	N/A	91	15	0.40
Zimbabwe	27	74	—	0.16
This report (using annual average costs)	(65)	(160)	65	0.38/0.64 ¹⁷
This report (using AIC)				0.47/0.77 ¹⁸

Source: WHO, 1992 Prices are for 1990

5.3.1.2 Uganda

The capital cost of urban water supply in Uganda is exceptionally high (shown in Table 5.15). Kayaga (1997) calculated the AIC (for recovering full capital and O&M costs) for NWSC (National Water and Sewerage Corporation), a major water utility at \$1.44 /m³. Table 5.16 quotes costs for RWS in Uganda taken from 'Policies and Guidelines of Uganda's Water Development Department for Rural Towns Water and Sanitation Programme' (1992).

Table 5.16. Costs of RWS in Uganda (1992)

Level of service	Construction cost		O&M cost	
	Ush/cap	US\$/cap	Ush /cap/year	US\$/cap/year
Piped supply to standpipe	30,000 to 60,000	30 - 60	2,000 to 5,000	2 - 5
Piped supply to yard tap	100,000 to 200,000	100 - 200	5,000 to 10,000	5 - 10

Source: WELL, 1998

¹⁷ \$0.38/m³ (R1.91) for O&M, \$0.64/m³ (R3.19) O&M + depreciation

¹⁸ \$0.47/m³ (R2.35) for O&M, \$0.77/m³ (R3.85) O&M + depreciation

5.3.2 South Africa

5.3.2.1 Financial modelling (PDG, 1996)

An extensive study was completed in South Africa in 1996 involving the financial modelling of RWS (PDG, 1996). The report synthesised the results of 5 regional studies in a report to DWAF. One of the aims of the project was to develop a district level strategic financial planning model. 467 villages affecting 1.2 million rural dwellers (in 5 geographic areas) were investigated. Three scenarios were chosen to investigate a range of levels of service (they are similar to Scenarios 4,5 and 6 in this report). Many of the assumptions made in this report are similar to those made by PDG in order to compare the results. A summary of the salient findings is shown in Table 5.17.

Table 5.17. Cost of RWS in SA (1995)

Scenario	Level of service (% of connectors)			Average total water demand	Capital cost	Operating cost ¹⁹	
	Standpipe	Yard	House			l/c/d	R/cap
1	77	12	7	76	532	1.52	18
2	53	32	14	89	650	1.40	19
3	42	38	20	105	826	1.53	24

Source: PDG, 1996 All prices in 1995 Rands, all inclusive

Tariffs: Average monthly bills for year 10: standpipe — R10 /house/month, yard taps — R55, and house taps — R85.

Appendix 5.10 illustrates the range of capital costs (for Scenario 2 of the 467 villages) in the PDG report compared with the 6 scenarios investigated in this report.

The per capital cost of this report are within the range of the PDG report. Running costs for the scenarios with a small water demand are significantly higher in this report — this is possibly due to economies of scale, different methods of costing and inflation.

5.3.2.2 Other SA figures

Durban Water and Waste offers a choice of supply to their customers of a low tank, a high tank and a full pressure connection. Connection fees are R175, R350 and R1,094 respectively. Low tank charges are fixed at R8.55/mon and the other two levels of service range between R1.15 and R3.12/m³, increasing depending on monthly consumption (PDG, 1997).

A recent exercise modelling tariffs for a local government structure in peri-urban and urban areas around Johannesburg (Timm, 1998) suggested charging R1.75, R2.65 and R3.79/m³ for increasing block tariffs of metered private connections. Public standpipes

¹⁹ Operating costs calculated for O&M + depreciation for year 10. Report states that 'unit costs are expected to be substantially higher in the early years when the infrastructure has been built but water demand is less than the designed capacity' (PDG, 1996). Operating costs are average figures: there is a substantial range within each of the districts and between districts.

charged at R9/month. The circumstances are very different to Seokodibeng, but it does give an indication of other charges for water supply in the country.

5.3.3 Others

Cairncross and Feachem (1993) quote the global average construction cost of RWS as US\$50 (R250) per capita in 1988.

DFID (1998) quote a rule-of-thumb monthly household costs for water supply outside the house (e.g. standpipe) of US\$5 (R25), and US\$10 (R50) for individual connections.

Costs in the case study compare favourably to all of these figures.

6.

Conclusion

The policy guiding the rural water sector in South Africa has followed international trends in trying to exploit the economic good of water as well as realising its social good. This has resulted in current policy requiring users to pay the recurrent cost of supply. In this policy environment, financial sustainability of projects is dependent on adequate cost recovery. Water Service Providers need to respond to consumer demand in order to exploit users' willingness to pay. Engineers need to design based on this effective demand. Effective demand for water means the quantity that consumers demand and are prepared to pay for at a particular price.

The demand-responsive approach gives a framework in which RWS projects can be implemented. This also requires a new approach to engineering. Designers should no longer apply standard supply-driven principles (such as fixed levels of service) but should design to meet demand.

Designing to meet demand requires the following new approach:

- demand needs to be assessed;
- consultation with stakeholders at different stages of the project; and
- a relationship between the service provider and the customer.

6.1 Findings

6.1.1 Demand-responsive approach

In 1998 11 million (65%) rural people in South Africa did not have access to an adequate water supply. The Department of Water Affairs and Forestry (DWAF) has responded to this problem by subsidising the capital cost of supplying a 'basic level of service': a communal standpipe to within 200m of households. Water Service Providers are expected to finance the recurrent cost of supply through user charges.

The aspiration of many communities is for a higher level of service. Cost recovery on most systems is non-existent and many are riddled with unauthorised connections. In order for financial sustainability, projects need to respond to effective demand. This is the demand that is backed up with the ability and willingness to pay for the supply.

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Willingness to pay will differ between levels of service: studies reveal that often high levels of service will have high WTP; whereas low levels of service often have low WTP — in SA there appears to be almost no WTP for a fixed ‘basic level of service’.

Supplying a fixed level of service is resulting in projects being implemented in a supply-driven approach. Engineers are designing RWS schemes to set per capita consumption estimates for standpipe supplies. This is not considering user preferences, local physical, socio-economic and institutional conditions. What is needed to improve sustainability is an approach that responds to demand. The ‘demand-responsive approach’ is an integrated approach to water provision with social, technical, financial and institutional dimensions. The primary measure of ‘demand responsiveness’ is the degree to which consumers have choices over the level of service of supply. Services should be based on these consumer preferences and charges set to recover the economic cost of supply.

The *theoretical* merits of a demand-responsive approach have been recognised by many researchers and by DWAF. Chapter 2 showed that many of these issues have actually been written into policy, but few have been applied to projects. This study investigated two aspects of *practically* implementing demand-responsiveness: demand assessment and designing for a mixed level of service.

6.1.2 Demand assessment

6.1.2.1 When to assess demand

Demand needs to be established throughout the project in order to respond to communities’ choices. Community participation in planning, design and implementation will increase demand-responsiveness. Two specific stages in the project cycle where demand assessment is required in the design process are:

- (i) *Identification/pre-feasibility*: Key principles of cost recovery need to be established between all the stakeholders and a broad range of technical options needs to be investigated; and
- (ii) *Feasibility*: Householders’ willingness to pay for different levels of service at estimated tariffs needs to be established and incorporated into design.

Demand-responsiveness requires an iterative process as demand affects design (costs and tariffs); and *visa versa*. The accurate estimation of demand needs to be carefully planned in order to inform design at the most appropriate stage of the project.

6.1.2.2 How to assess demand

Demand assessment techniques can be classified as either *direct methods* (stated preferences); or *indirect methods* (revealed preferences).

The favoured direct valuation method for water supply projects is the contingent valuation method. CVM is possibly the most reliable method of eliciting households WTP for an improved supply and it can be useful in predicting the levels of service households will choose when offered a mixed level of service. CVM should be considered to inform

CONCLUSION

policy to strike a balance between subsidy and user charges. However, at a project level, CV surveys will generally be too expensive and time consuming for small rural projects. The economic rigour needed for accurate estimation of WTP is inappropriate to the sensitivity of the other design assumptions. Also, the link between assessing WTP and setting tariffs is also not clear and the replicability of CV findings is poor.

Indirect methods can use proxy indicators of demand e.g. village size, payment to water vendors. Participatory techniques can be used in community meetings or focus groups. Up-front indicators of commitment to the project e.g. contribution to an O&M fund, have been shown to be good indicators of demand.

Demand assessment methods can be used in tandem. The more measures a designer takes to establish effective demand, the more reliable the assessment should be. It may not always be possible to meet felt needs, or even offer acceptable levels of service within an affordable range, but demand-responsiveness should attempt to allow the decision as to the choice of supply to be made by the user. In small RWS projects, the most practical method of encouraging demand-responsiveness is through extensive community participation. PRA techniques can be very effective in eliciting demand.

6.1.3 Designing for a mixed level of service

If design is to respond to demand, and demand varies within a community as to the willingness to pay for particular levels of service, projects need to be designed for a mixed level of service to meet these varied demands. The case study of Seokodibeng village considered 3 hypothetical mixed levels of service: Scenario 4, 5 and 6. Analysis showed the following technical and financial implications for design.

6.1.3.1 Engineering design

Predicting water demand

Design engineers need to base their designs on predicted consumption. Engineers have traditionally used consumption levels to reach minimum health requirements e.g. 25 l/c/d or estimates of consumption relative to levels of service e.g. 80 l/c/d for a yard connection. To the engineer, designing to meet demand means more accurate estimation of that consumption figure, be it 43 or 58 l/c/d. This needs to be informed by the demand curve predicting customers' willingness to pay.

Many assumptions are made by engineers designing RWS. Predicting the proportion of customers that will connect to different levels of service adds another factor to these assumptions. Water demand is determined by:

- initial demand;
- change in demand: influenced mainly by population growth and upgrading;
- expected consumption relative to level of service (a reliable guideline value needs to be chosen);

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- unaccounted for water; and
- design criteria: in particular, peak factors and design parameters for different system components.

The case study revealed that estimates of population growth had a 250% impact on demand (between upper and lower estimates) and upgrading estimates differed by 240%. This affects water demand significantly more than predicting the initial base year demand (120% difference between Scenario 4 and 6).

Staged construction

Different system components need to be designed to different design horizons. Source and storage can be designed for the present demand, but distribution needs to cater for projected future demand (perhaps 20 years). The increase in pipe diameter from Scenario 4 to 6 increases distribution costs by 40%, however the consequence of not catering for increased demand is significantly more costly. Most importantly, systems must allow for individuals to upgrade their level of service.

Financing

The infrastructure needed to supply higher level of service is larger and more sophisticated than lower level of service. Capital costs will be higher and this will need to be financed through subsidy mechanisms or moved onto the customer. However, recurrent costs for higher levels of service are lower per unit of water through economies of scale, therefore the cost of production decreases as demand increases.

What can we conclude from the case study?

- Tariffs can be structured similarly regardless of the initial demand scenario;
- Significant economies of scale exist as can be seen in the reducing O&M cost with the increased demand;
- Initial demand assessment exercises (for example in the case study, establishing whether the demand is Scenario 1, 2 or 3) has significance to the capital cost financing, as expected. However the change in demand over the project life (due primarily to upgrading and population growth) is potentially of greater significance to the design than estimating the initial demand. This questions the importance of accurate demand assessment prior to design relative to assessment of other design parameters.

Demand assessment is needed to estimate initial demand i.e. proportion of households choosing different levels of service. This assessment will determine the capacity of the system (and therefore the capital cost), but will have little impact on tariffs. In general, designing for a mixed level of service has the following financial implications:

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- *subsidy*: current subsidy is set at the capital cost of a basic level of service. If systems are to be designed to allow for a mixed supply, the capital cost will increase. The difference in capital cost between the subsidy and the actual cost needs to be financed, either through tariffs or some other means. Subsidies are a mechanism for wealth redistribution, but need to be used with care in order to signal the economic cost of supply to the consumer;
- *cross-subsidy*: can enable individual connectors (and other users) to subsidise standpipe users, however the price elasticity of demand, and the proportion of individual connectors will dictate the extent to which cross-subsidy is possible;
- *tariffs*: are complex to model. Theoretically, there are a myriad of tariffing options. Practically, it is sensible for standpipe users to pay flat rates and individual connectors a metered rate. In order to satisfy equity and financial objectives, it is recommended that communal standpipe users be charged a tariff linked to the O&M of a basic level of service (also considering affordability); and individual connections be charged the ‘average incremental cost’ of the O&M, depreciation and capital cost (difference between the subsidy amount and the actual cost) of supply. Tariffs will also be affected by political, institutional and social issues; and
- *loan finance*: is necessary for micro-financing of individual connections and financing bulk infrastructure. Additional capital expenditure can be financed through tariffs, but loan finance will need to be available to finance the initial negative cash flows.

6.1.4 Limitations

Many of the findings argue for a new approach to RWS design. This approach is not limited to Seokodibeng nor the Northern Province. The notion of a mixed level of service, however may have specific application to South Africa or similar countries (politically and economically). One of the most important questions that needs to be asked is whether rural economies can support a mixed level of service. This study does not answer that question. The following data are necessary in order to determine this:

- average income and income distribution statistics;
- accurate assessment of willingness to pay;
- case studies testing actual behaviour.

Mixed levels of service have been used by designers in the urban sector (usually termed ‘service differentiation’) to a limited extent. Offering these options in rural areas may not be practical for many WSP. This is largely an issue of institutional capacity and may be the limiting factor in most areas.

The literature relies heavily on demand assessment techniques developed by the World Bank — these have a bias for larger, urban schemes where the funds are given with little involvement of the beneficiary community. None of these techniques have been rigorously tested in SA, and few on small water projects. Little work has been done in SA on

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WTP and the conclusions of this study are informed largely from experience in other countries.

The case study made many assumptions in design aspects — from water demand to cost recovery options — in order to illustrate the methodology. The resultant recommended tariffs are specific to Seokodibeng and to the assumptions that have been made. It is more useful to note the sensitivity of the design on the assumptions than any of the actual figures.

If projects are to respond to demand, a broad range of technical options needs to be offered to communities. In this case study, it may also have been beneficial to consider options for a lower-than-basic level of service e.g. handpumps.

Sanitation and health promotion are equally important to water supply in realising health benefits. RWS projects should not be considered in isolation. This study has focused on water supply for simplicity.

This study has also focused on financial sustainability. Institutional aspects have been omitted but are also crucial to sustainability.

6.2 Recommendations

6.2.1 Policy

Lessons from the demand-responsive approach need to shape future government policy regarding technical, social, financial and institutional interventions. The following issues should inform the subsidy debate:

- Policy must move away from supplying a basic level of service, to responding to the type of supply and level of service for which communities are willing to pay;
- A mechanism whereby subsidy allocations can be fixed, but still respond differently to different village demands needs to be developed; and
- If policy is to support a mixed level of service, loans needs to be available to WSP to finance the increased capital cost.

6.2.2 Project design

- Demand assessment needs to be done at project identification and feasibility stage;
- Mixed levels of service need to be considered in project design;
- It is sensible for tariff policy to separate consumers in (at least) two categories:
 - Communal standpipe users: tariff linked to the O&M cost of a basic level of supply;
 - Individual connectors: should pay the long-run marginal cost e.g. AIC of O&M, depreciation and the capital cost needed to be financed through the project. The

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demand for individual connections needs to be demonstrated by up-front payment of a portion of the connection cost.

Technical and financial issues need to be considered alongside other project perspectives. The institutional arrangement and level of community participation is particularly pertinent to enable demand-responsiveness.

6.3 Further research needs

Significant government funds are being poured into the RWS sector. The sustainability of these projects is under threat. Designing to meet demand is potentially the most significant factor currently affecting the sustainability of RWS projects in SA. There is an urgent need for conclusive research in this area. The following are some possible focus areas:

- how government subsidies can better incorporate demand-responsive principles;
- appropriate demand assessment methods:
 - factors affecting willingness to pay in SA;
 - methods that enable ‘benefit transfer’ in demand assessment techniques;
 - closer links between WTP results in CV surveys and actual costs;
 - use of CVM in pilot areas to inform national policy;
 - practical ways in which engineers can use the results of CV studies to match costs, WTP and tariffs
 - low-cost, less rigorous use of CV methodology that can be used by planners and designers in small RWS schemes
 - method of using CVM methodology — without the economic rigour — for small RWS projects;
- design: — how to offer customers a broader range of technical options e.g. LOS, technology:
 - methods of predicting upgrading over project life;
 - methods of encouraging and improving WTP of customers: this is outside of the scope of this report, but obviously a key consideration for project success.

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