A WEDC MSc Study in 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

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Technical and Financial Implications of Designing to Meet Demand

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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 (DWAF) 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.

DWAF 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

DWAF 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 DWAF policy states that users should pay the recurrent costs of supply, payment levels on current projects are negligible. DWAF 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 DWAF 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 timeconsuming to conduct and attempts to estimate demand to an accuracy inappropriate to small projects.

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).

Table 1. Mixed levels of service

	Unit	*Scenario*		
Base year demand		**1**	**2**	**3**
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

(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
m^3/d	Cubic metres (or kilolitres — kl) per day
NGO	Non-government organisation
NPV	Net Present Value
O&M	Operation and maintenance
p.a.	Per anum
PRA	Participatory Rural Appraisal
RDP	Reconstruction and Development Programme
RWS	Rural water supply
SA	South Africa
UFW	Unaccounted for water
VLOM	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

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.

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 wide-spread 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):

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);

- 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

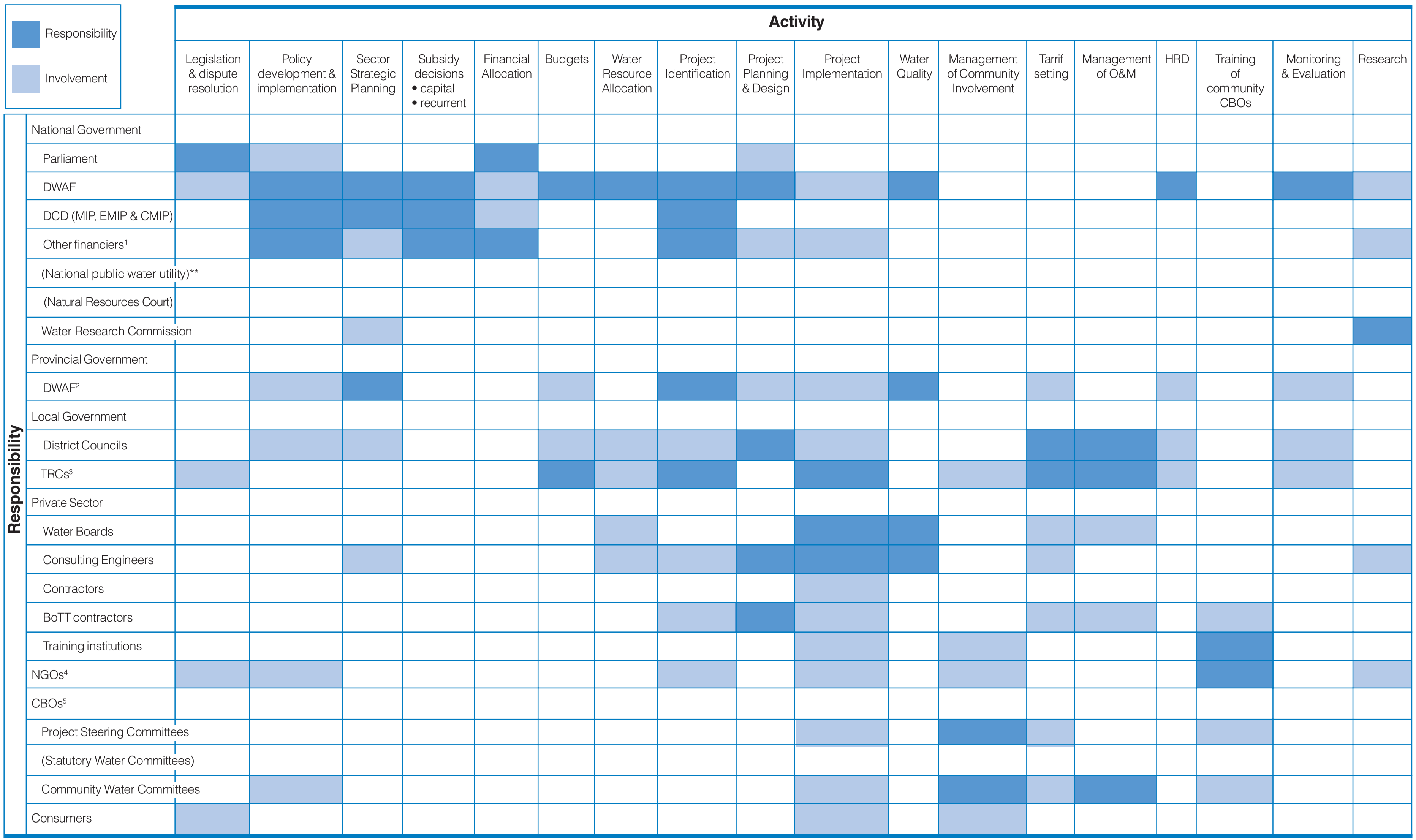
In the past, no single agency was responsible for RWS in the country (Tainton, 1997). There was considerable overlap of responsibility within the water sector between central government departments, former 'homeland'[1] governments, parastatals and water boards. The White Paper (DWAF, 1997a) proposes 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

- *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).



** 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

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).

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

Level of service	*Description*	*% coverage*
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 sustainablity 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.

Figure 2.2. Factors affecting sustainability

Sustainability

Technical

- Alternative/existing water sources
- Quantity, quality, reliability and convenience of supply
- Appropriate technology:
  - design to meet long-term demand (not fixed supply assumptions)
  - accurate consumption vs. level of service data
  - mixed level of service (householders choose between options) (may be higher of lower than 'basic level of service' — 25 l/c/d to within 200m)
  - service levels are designed on WTP
  - upgradability
  - VLOM
- Acceptable quality of workmanship during construction
- Preventative maintenance is carried out
- Spare parts are available
- Unaccounted for water is within acceptable limits

Political/Legal

- Political stability and consistent policy
- Support from other ministries: Health, Public Works, Constitutional Affairs, Education, Housing
- Equitable water rights
- State owns all water resources
- Land tenure
- Political pressure to 'deliver' water supply does not compromise sustainable approaches
- Payment for services is communicated effectively (and accepted) by politicians
- Local authorities have recourse to prevent unauthorised connections

Economic

- Economic growth and stability
- Local economies integrated into national
- Economic viability of project
- Accurate assessing of demand: direct (e.g. CVM) and indirect (revealed preference) methods
- Affordability of supply ('ability to pay')
- 'Willingness to pay' for different levels of service

Environmental

- Effective water resource management (catchment management)
- Environmental protection
- Water supply does not exceed water availability (SA is water-stressed)
- Domestic water is given priority over other productive uses e.g. agriculture
- Water scarcity may limit economic growth e.g. agriculture, industry

Social

- Demand-driven process i.e. community and households choose type of supply and level of service
- Existing racial/economic disparity in levels of service
- Social marketing of service (not project)
- Acceptance of government policy of cost recovery
- Health and hygiene education to promote health impact of improved water supply and therefore create 'true' demand
- Behavioural change and empowerment
- Involvement of women, particularly in decision-making
- User/beneficiary involvement at most stages in project cycle
- Community will remain in village over design life

Financial

- National budget allocation to DWAF, DCD, other funders
- Financial allocation to RWS
- DWAF subsidy of capital cost of projects
- Clarity on DWAF subsidy for higher than basic level of service
- Clear financial objectives e.g. recovery of all recurrent costs by tariffs
- Financial viability of projects (FIRR > opportunity cost)
- Tariff set to meet financial objectives reflecting WTP for service (*CAFES: conserving, affordable, fair, enforceable and simple*)
- Grant/loan financing available for yard/house connections

Institutional

- DWAF policy and planning
- Clear roles and responsibilities, particularly Water Service Authority, Water Service Provider and community
- Institutional support of local government by national, province and district
- Co-ordination between DWAF, Local authorities, Communities and Implementing Agents (private sector, NGO's, BOTT contractors)
- Efficiency and effectiveness of responsible institution
- Replicability of approach
- Capacity of local government
- Community management and participation
- Training of communities in O&M
- Adequate 'social intermediation' and training

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 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.

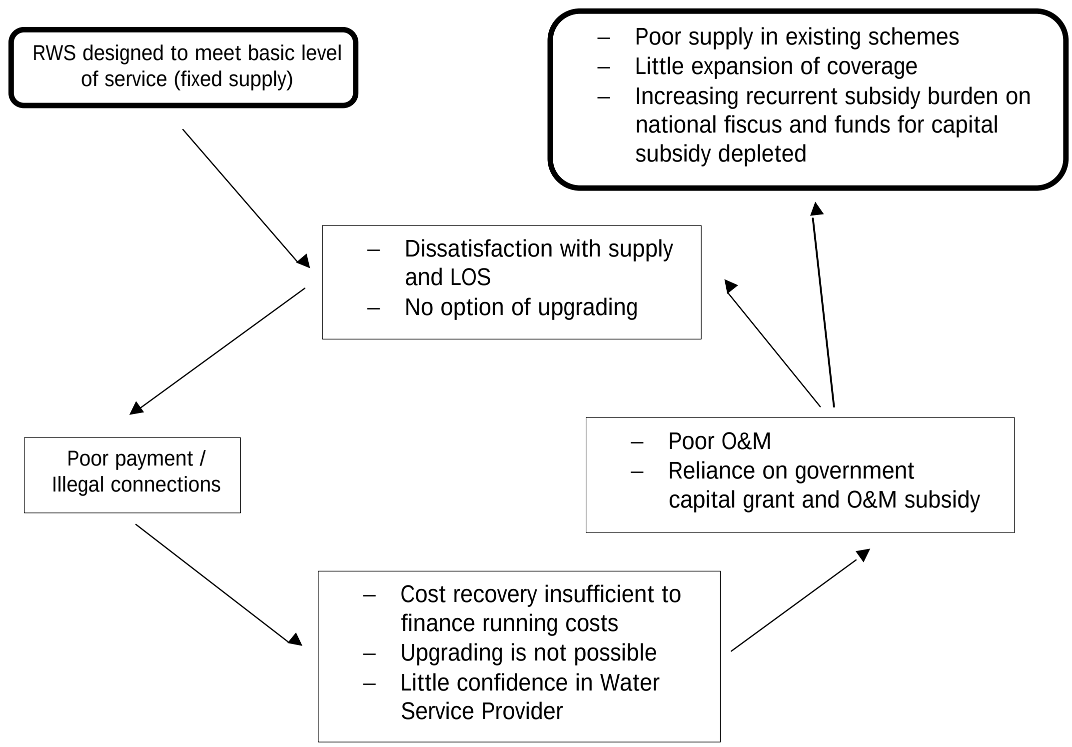


Figure 2.3. Consequence of a supply-driven approach

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

- 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[1]* Adapted from WHO, 1994

Chapter 2 argues that the key problem of the sustainability of RWS projects in SA as 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 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 perceivably continue over the next decades. The externalities [2] 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):

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

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)

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.

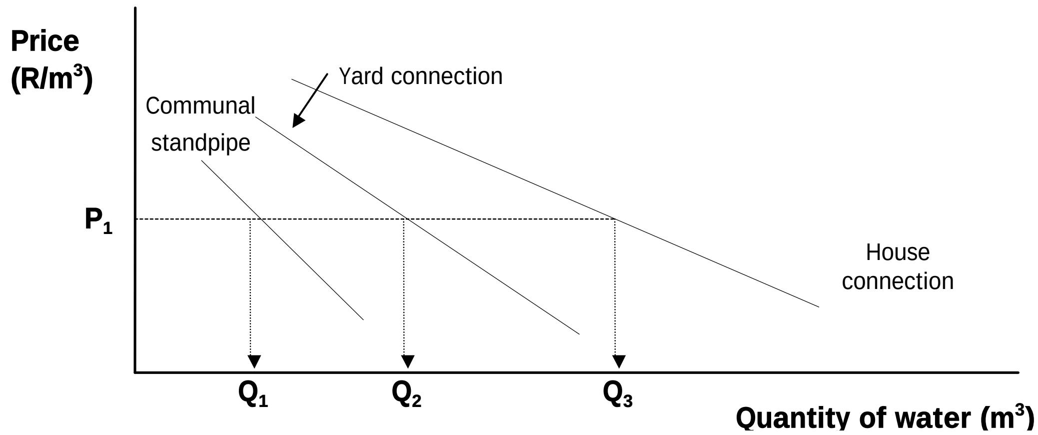


Figure 3.1. Demand curves for different levels of service

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:

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

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. Ed = 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.

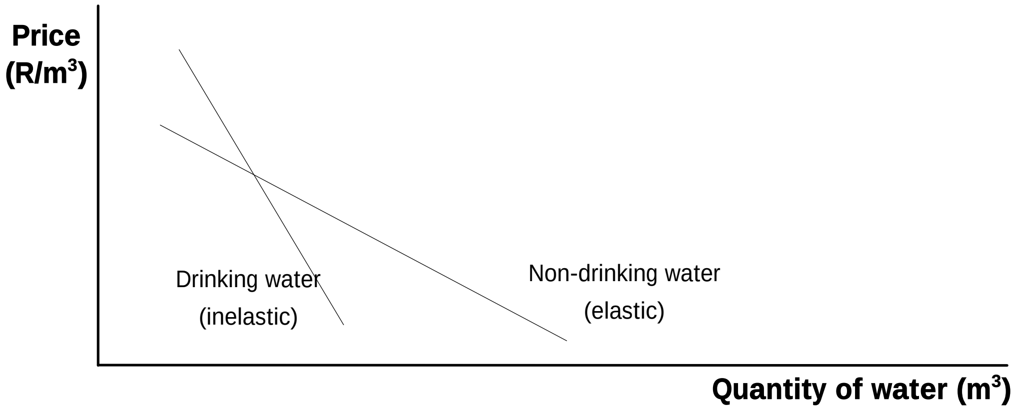


Figure 3.2. Aggregation of water demand curves

Source: Adapted from Lovei (1992)

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 > 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 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 campaign[4] — 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 (Zoio, 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.

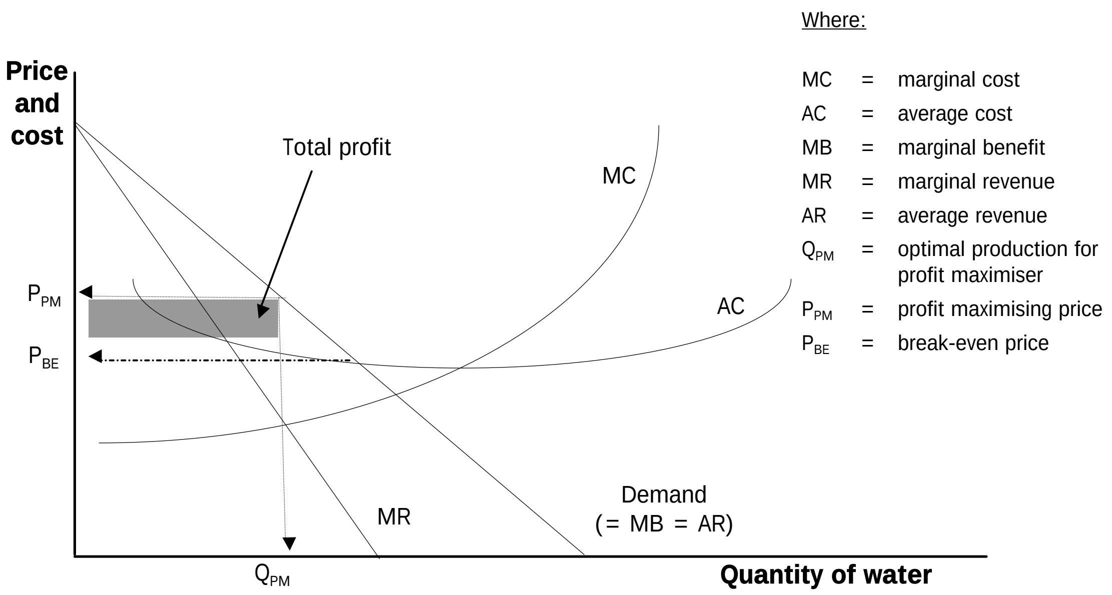


Figure 3.3. Profit maximising price

Source: Adapted from Pearce, 1981

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.

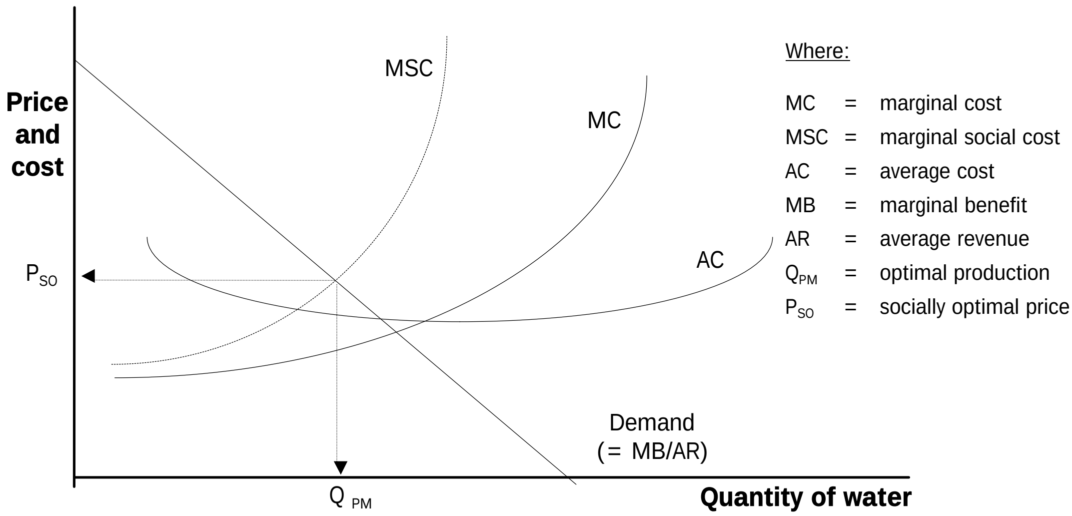


Figure 3.4. Marginal costing

Source: Adapted from Barker, 1998

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:

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

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;

- 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).

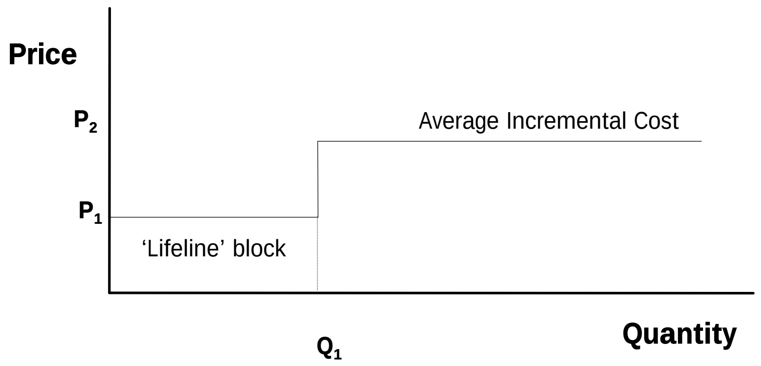


Figure 3.5. Increasing block tariffs

Source: Franceys (1994)

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 m^3 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;

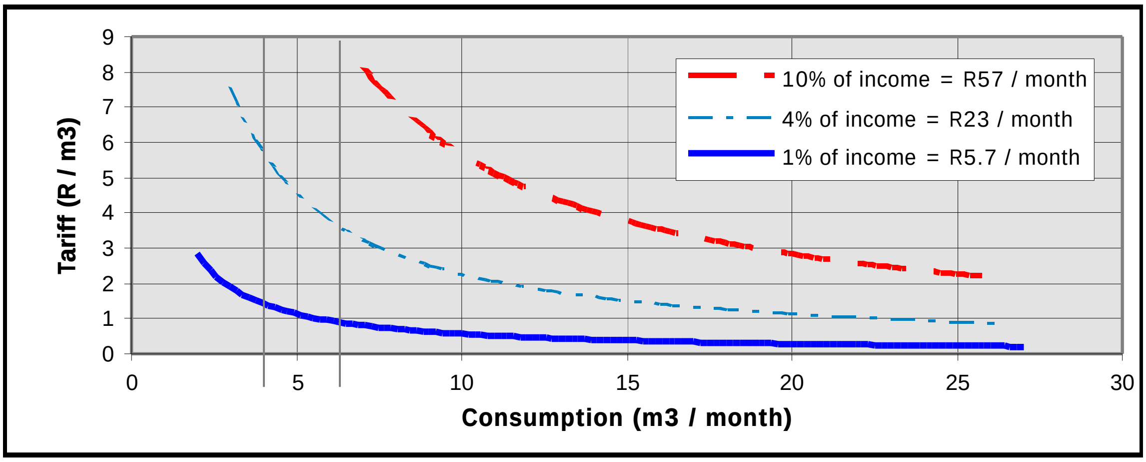
(ii) average income and income distribution;

(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).

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 m^3/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/m^3 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 /m^3); 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;

- 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 economists 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/m^3; although the suspected average cost is $0.75/m^3 (World Bank, 1990);
- In Lima, Peru, water vendors sell water for $3/ m^3 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 subsides 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/m^3 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 m^3/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):

- 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).

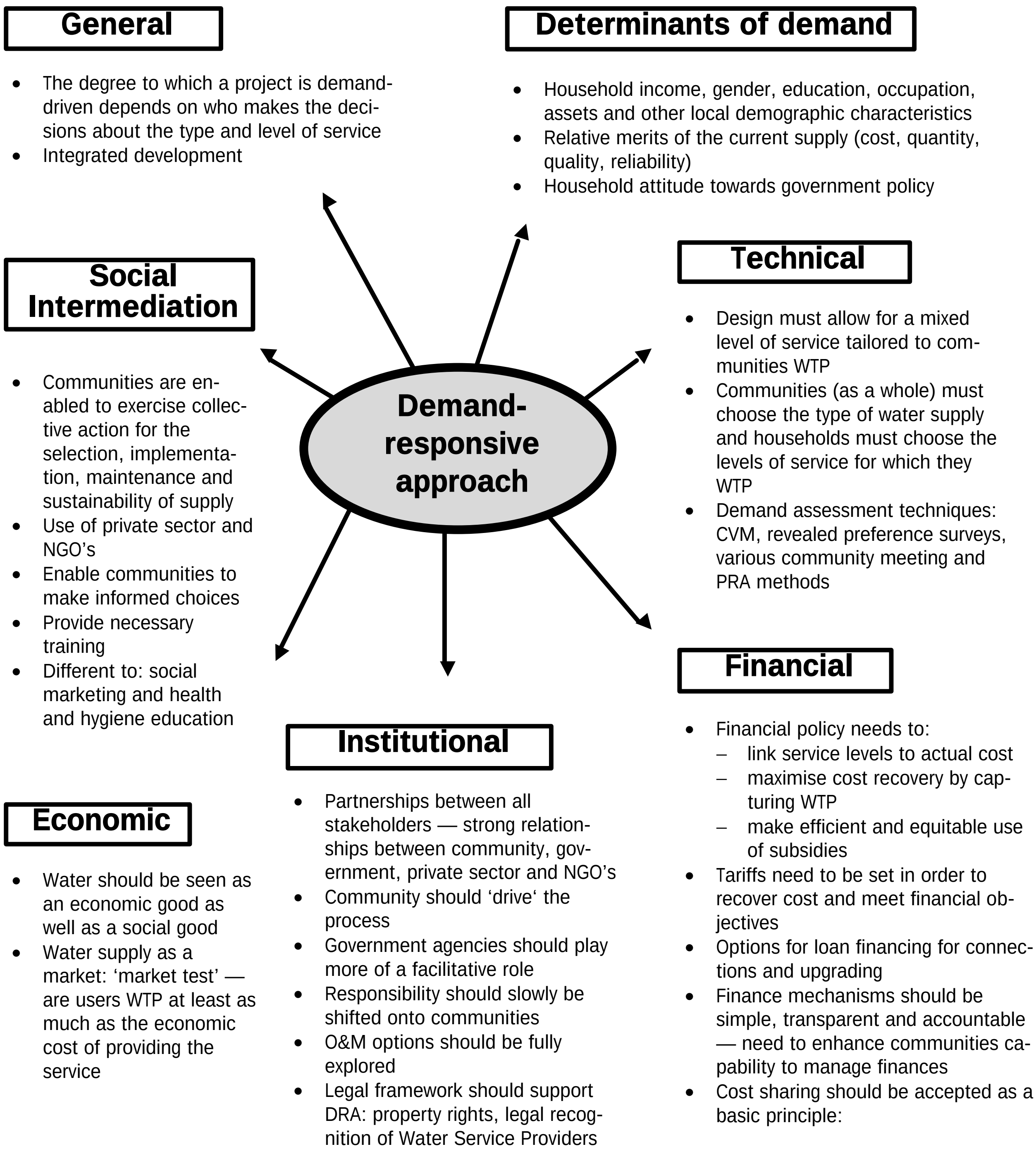


Figure 4.1. Perspectives within the demand-responsive approach

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.

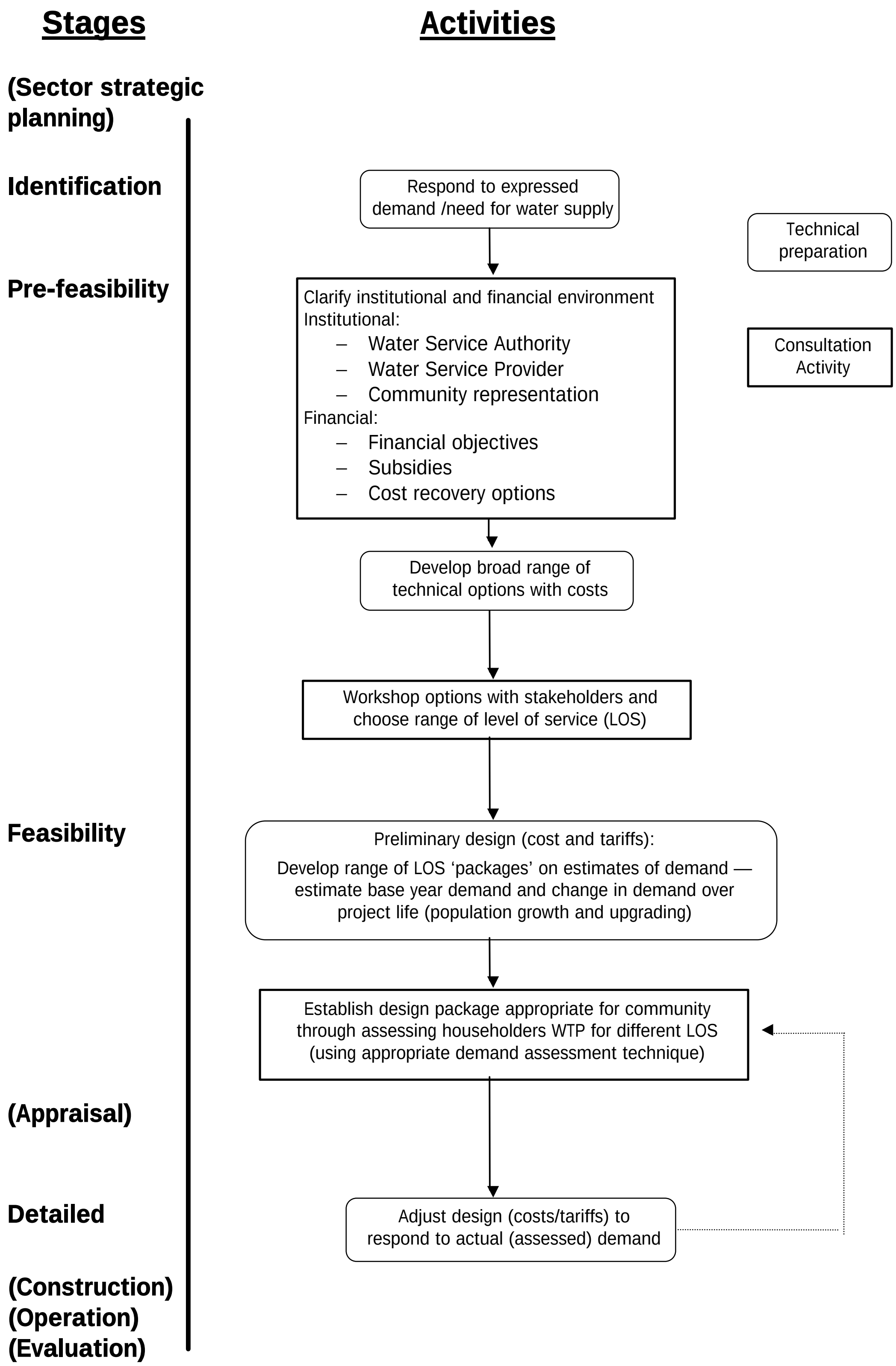


Figure 4.2. Demand-responsive project cycle

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 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

Scenario	*Description*	*Reason for choosing scenario*
	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

Increased demand due to	*% p.a.*
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 m^3/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 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

Level of service	***Water consumption (l/c/d)***					
	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 a 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.

(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

	Domestic	***Institutions***	***UAW***	***Total (average equivalent)***	
Scenario	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 m^3/d; this is averaged into an equivalent per capita demand in l/c/d.

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

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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

	Daily peak	***Seasonal peak***	***Total distribution peak***
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 (m^3/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 standpipe 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 Pieterburg.

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 is 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.***

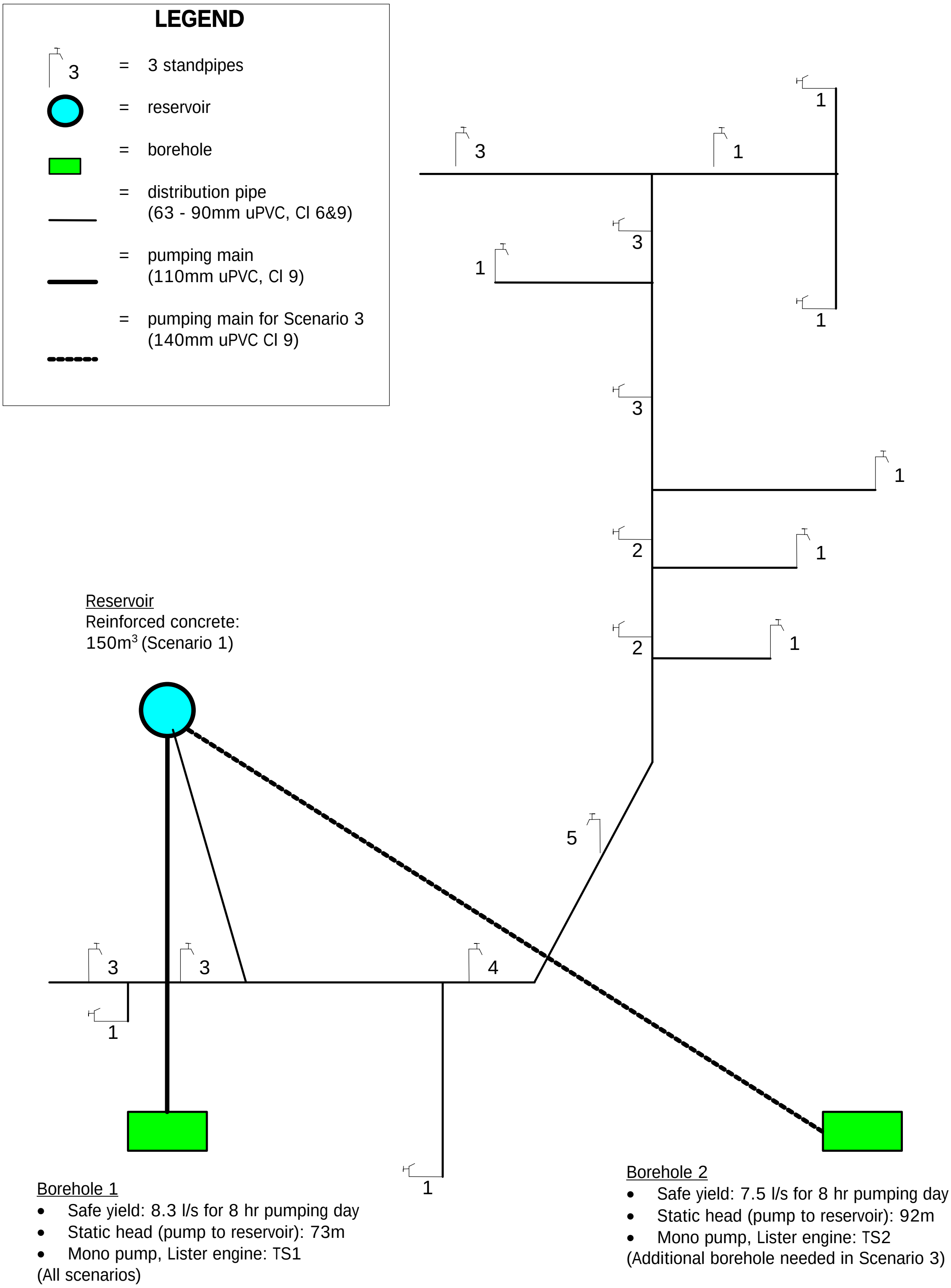


Figure 5.1. Schematic layout for Scenario 1

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/m^3) 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 Vienings, 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 2m^3 per day was used for trenching); and
- Individual connection costs are included in the recurrent costs, communal standpipes are within the capital costs.

Table 5.7. Capital costs

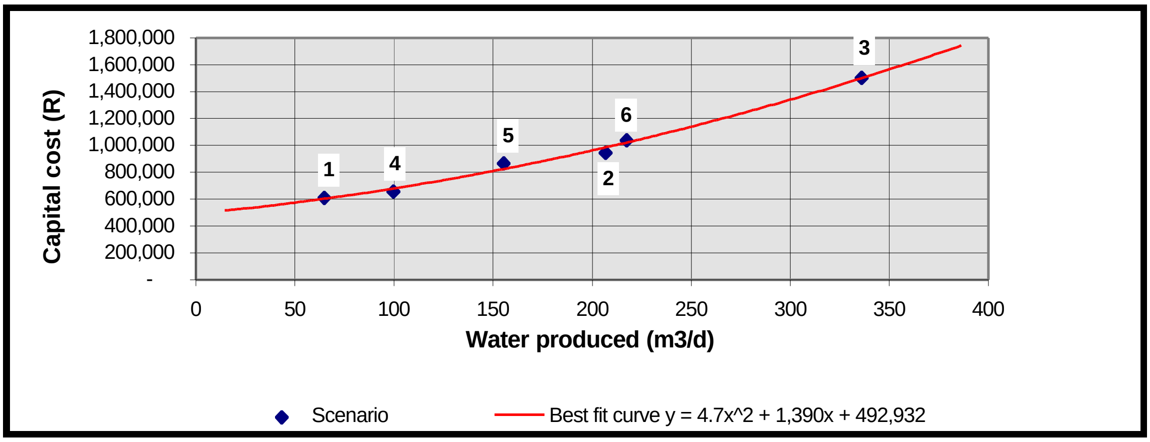
Scenario	*Water produced (m^3/day)*	*Source development*	*Storage*	*Distribution*	*Professional*	*Total*	*R/ capita*	*Ratio*
1	65	100,370	111,900	259,858	135,678	607,807	324	1
2	207	150,154	335,700	298,828	157,854	942,538	503	1.6
3	336	351,227	522,200	414,127	215,181	1,502,738	802	2.5
4	100	117,948	149,200	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 m^3/day — the difference between water produced and water consumed, in this case, is the component termed unaccounted for water).

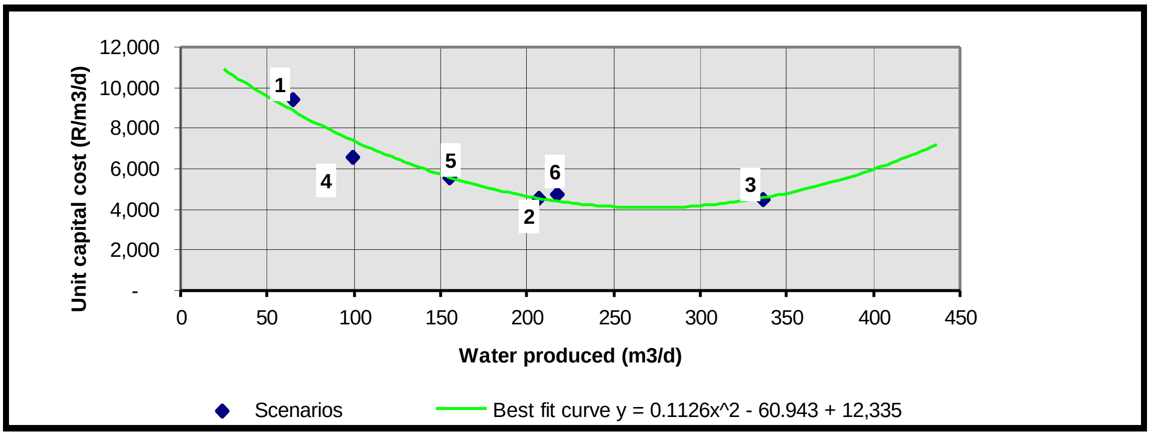
Graph 5.1 plots the total capital cost against the potential daily water production. A summary of total costs and water production is shown in ***Appendix 5.6***. Per capita capital cost are shown in Table 5.7 in order to inform possible subsidy decisions.

Graph 5.1. Capital costs



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 m^3/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)

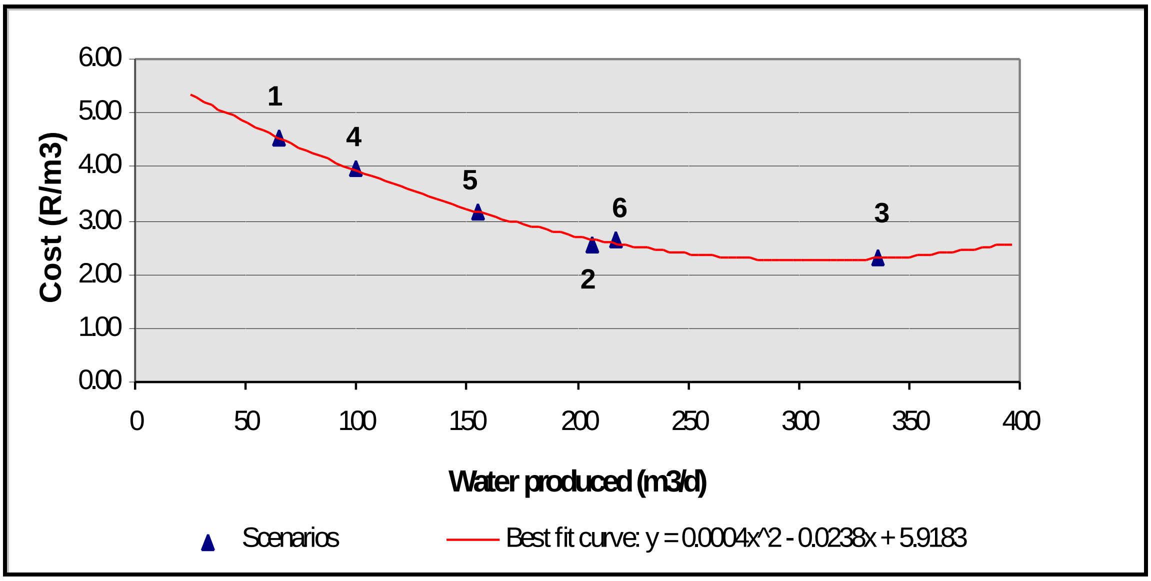
Table 5.9. Recurrent costs

Scenario	***Water produced***	***O&M***			***O&M + depreciation***		
	m^3/day	R/mon	R/mon/ house	R/m^3	R/mon	R/mon/ house	R/m^3
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

Tariffs based on recovery of:	*Tariffs for different scenarios (R/m^3)*					
	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

Tariffs based on:	***Tariffs in different years (R/m³)***		
	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)

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/m^3);
- 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***
	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 villagers 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.

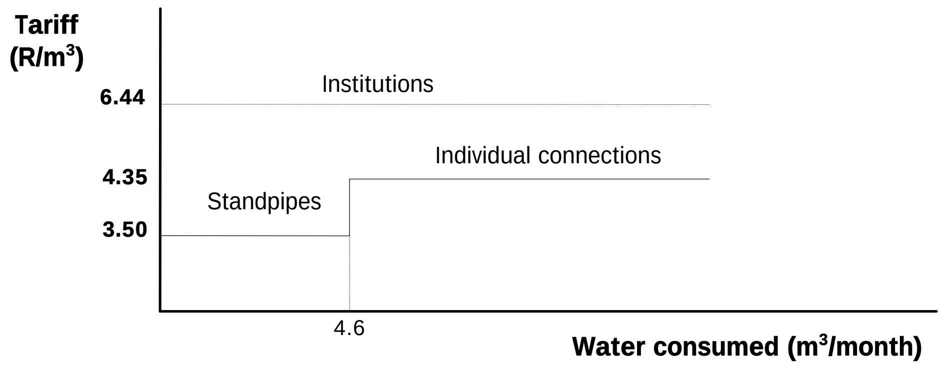


Figure 5.2. Graphical representation of recommended tariff structure

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

Tariffs to recover:	***AIC (R/m^3)***		
	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:

- '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 > 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

	Unit	*Option 1*	*Option 2*	*Option 3*
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 $\$0.25/m^3$, although the suspected actual cost of supply (calculated from the AIC) was $\$0.75/m^3$ (Franceys, 1998). Table 5.15 is taken from findings of the IDWSSD. It is interesting to see the vast range of costs.

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 /m^3. 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)

	Construction cost		***O&M cost***	
Level of service	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/m^3 (R1.91) for O&M, $0.64/m^3 (R3.19) O&M + depreciation

[18] $0.47/m^3 (R2.35) for O&M, $0.77/m^3 (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	R/m3	R/house/mon
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/m^3, 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/m^3 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.

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 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);

- 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 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:

- *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

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

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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Appendices

5.1 Water demand for no change in level of service
5.2 Water demand for changing level of service
5.3 Pipe layout and pipeline design for Scenario 1: all communal standpipes
5.4 Source of cost data and cost of connections
5.5 Capital and recurrent costs: Scenario 1 to 6
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Appendix 5.1 Water demand for no change in level of service

Population

	Years	People	Houses
Population in 1994		1,698	283
Present population 1998	0	1,874	312
Design life Year 2008	10	2,399	400
Design life Year 2018	20	3,071	512
People per household *1	6		
Population growth rate *2	2.5%		

Demand per level of service

	Unit	Scenarios					
		1	2	3	4	5	6
		all cs	all yc	all hc	mixed	mixed	mixed
Domestic demand per level of service	(l/c/d)	25	80	130			
Communal standpipe (cs)					80%	50%	20%
Yard connection (yc)					15%	35%	50%
House (kitchen) connection (hc)					5%	15%	30%
Average domestic demand	(l/c/d)	25	80	130	39	60	84
Institutional Demand (schools, clinics, churches, tribal authority, etc.)	15%	4	12	20	6	9	13
Subtotal	(l/c/d)	29	92	150	44	69	97
Unaccounted for Water	20%	6	18	30	9	14	19
Total demand per level of service (lcd) *4	**(l/c/d)**	**35**	**110**	**179**	**53**	**83**	**116**

Average Annual Daily Demand

	Unit	1	2	3	4	5	6
AADD - Present (1998)	(kl/d)	65	207	336	100	155	217
	(l/s)	0.7	2.4	3.9	1.2	1.8	2.5
AADD - Year 10 (2008)	(kl/d)	83	265	430	127	199	278
	(l/s)	1.0	3.1	5.0	1.5	2.3	3.2
AADD - Year 20 (2018)	(kl/d)	106	339	551	163	254	356
	(l/s)	1.2	3.9	6.4	1.9	2.9	4.1

Peak Factors

	1	2	3	4	5	6
Daily peak *5	3	2.6	2.4	2.9	2.8	2.6
Seasonal peak *3	1.2	1.35	1.5	1.2	1.35	1.4
Distribution peak (daily peak x seasonal peak)	3.6	3.5	3.6	3.5	3.7	3.7

System components:

	Design parameters *6	Unit	1	2	3	4	5	6
Source development	AADD (present) safe yield for 8hr pumping/day	(l/s)	2.2	7.2	11.7	3.5	5.4	7.5
Pumping main	same as source	(l/s)	2.2	7.2	11.7	3.5	5.4	7.5
Storage	AADD (present) x 48hr storage	(kl/d)	129	414	672	199	310	435
Distribution	AADD (Year 20) x Peak flow	(l/s)	4.4	13.8	23.0	6.6	11.0	15.1
Minimum standpipe yield (0.17 l/s) to 37 s/p		(l/s)	6.3					

Footnotes

*1 National average is taken as 5.6 people per household (CDE, 1995) - local survey shows around 6 people per household
*2 Estimate of local average. National average = 1% (CDE, 1995); other estimates in the area = up to 4.4%
*3 Van Schalkwyk (1996)
*4 Note: other water uses not taken into account e.g. stock watering, irrigation etc.
*5 Daily peak includes reticulation peak factor (RPF), Reticulation loss (RL), & Down time Losses (DT) (DWAF, 1997b)
*6 Adapted from DWAF design guidelines (DWAF, 1997b)

Appendix 5.2 Water demand for a changing level of service

Initial level of service as per scenario 4

Assumptions:	
Population growth =	2.5%
Annual increase in yard connections *1 =	4%
Annual increase in house connections *2 =	4%

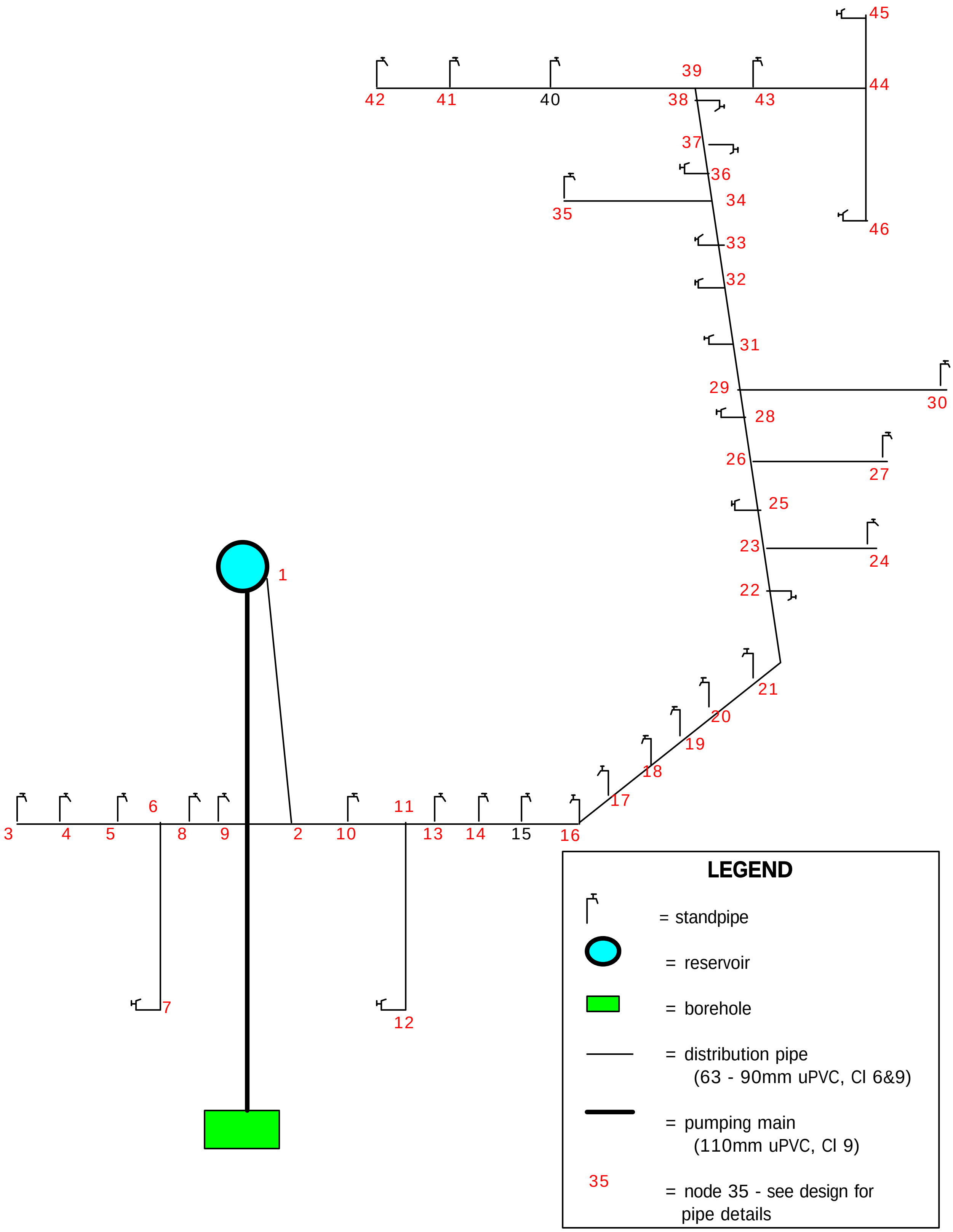
Demand per level of service (l/c/d):	
Communal standpipes	25
Yard connections	80
House connections	130

Year	Houses	Pop.	Connections						Water demand per connection (kl/d)			Domestic AADD		Institutional demand	Instit. + domestic	UFW	Total AADD	
			cs	yc	hc	cs	yc	hc	cs	yc	hc			15%		20%		
			%	%	%	no.	no.	no.	kl/d	kl/d	kl/d	kl/d	l/c/d	kl/d	kl/d	kl/d	kl/d	l/c/d
1	312	1,872	**80%**	**15%**	**5%**	250	47	16	37	22	12	72	39	11	83	17	**99**	53
2	320	1,919	79%	16%	5%	253	50	17	38	24	13	75	39	11	86	17	**103**	54
3	328	1,967	78%	16%	5%	257	53	18	39	26	14	78	40	12	90	18	**107**	55
4	336	2,016	78%	17%	6%	260	57	19	39	27	15	81	40	12	93	19	**112**	55
5	344	2,066	77%	18%	6%	264	60	20	40	29	16	84	41	13	97	19	**116**	56
6	353	2,118	76%	18%	6%	267	64	21	40	31	17	88	41	13	101	20	**121**	57
7	362	2,171	75%	19%	6%	270	69	23	41	33	18	91	42	14	105	21	**126**	58
8	371	2,225	74%	20%	7%	273	73	24	41	35	19	95	43	14	109	22	**131**	59
9	380	2,281	73%	21%	7%	276	78	26	41	37	20	99	43	15	114	23	**137**	60
10	390	2,338	72%	21%	7%	279	83	28	42	40	22	103	44	16	119	24	**143**	61
11	399	2,396	70%	22%	7%	281	89	30	42	43	23	108	45	16	124	25	**149**	62
12	409	2,456	69%	23%	8%	283	95	32	42	45	25	112	46	17	129	26	**155**	63
13	420	2,518	68%	24%	8%	285	101	34	43	48	26	117	47	18	135	27	**162**	64
14	430	2,581	67%	25%	8%	287	107	36	43	52	28	123	47	18	141	28	**169**	66
15	441	2,645	65%	26%	9%	288	115	38	43	55	30	128	48	19	147	29	**177**	67
16	452	2,711	64%	27%	9%	289	122	41	43	59	32	134	49	20	154	31	**185**	68
17	463	2,779	63%	28%	9%	290	130	43	43	62	34	140	50	21	161	32	**193**	69
18	475	2,848	61%	29%	10%	290	139	46	43	67	36	146	51	22	168	34	**202**	71
19	487	2,920	59%	30%	10%	289	148	49	43	71	38	153	52	23	176	35	**211**	72
20	499	2,993	**58%**	**32%**	**11%**	289	158	53	43	76	41	160	53	24	184	37	**221**	74

*1 Related to increase in GGP, tariff and other 'value orientation' factors (van Schalkwyk, 1996)
*2 Increase in house connections are assumed to be households upgrading from yard connections to house connections

Appendix 5.3 Layout of pipes and nodes

Scenario 1: Communal Standpipe design



Appendix 5.3 Pipeline design - Communal Standpipe

Designed using 'BRANCH' software: Modak & Dhoondia (1991) BRANCH - Version 3, The World Bank, Washington, USA

Number of Pipes : 45
Number of Nodes : 46
Number of Commercial Diameters : 13
Peak Design Factor : 1
Minimum Headloss in m/km : .001
Maximum Headloss in m/km : 100
Minimum Residual Pressure m : 10
Total cost (including VAT less discount) R 148,890

Pipe Data

Pipe; No.	From; Node	To; Node	Length m
1	1	2	210.00
2	3	4	150.00
3	4	5	150.00
4	5	6	30.00
5	6	7	50.00
6	6	8	100.00
7	8	9	125.00
8	9	2	120.00
45	2	10	60.00
9	10	11	100.00
10	11	12	100.00
11	11	13	100.00
12	13	14	190.00
13	14	15	190.00
14	15	16	190.00
15	16	17	190.00
16	17	18	190.00
17	18	19	190.00
18	19	20	190.00
19	20	21	190.00
20	21	22	190.00
21	22	23	210.00
22	23	24	60.00
23	23	25	180.00
24	25	26	181.00
25	26	27	100.00
26	26	28	200.00
27	28	29	5.00
28	29	30	150.00
29	29	31	155.00
30	31	32	220.00
31	32	33	250.00
32	33	34	87.00
33	34	35	500.00
34	34	36	150.00
35	36	37	50.00
36	37	38	150.00
37	38	39	150.00
38	39	40	220.00
39	40	41	220.00
40	41	42	220.00
41	39	43	30.00
42	43	44	170.00
43	44	45	30.00
44	44	46	300.00

Node Data

Node; No.	Peak; Factor	Flow; lps	Elevation; m	Residual Pressure m
1	1.00	0.000	100.00	10.00
2	1.00	0.000	67.00	10.00
3	1.00	-0.170	82.00	10.00
4	1.00	-0.170	79.00	10.00
5	1.00	-0.170	77.00	10.00
6	1.00	0.000	76.00	10.00
7	1.00	-0.170	73.00	10.00
8	1.00	-0.170	70.00	10.00
9	1.00	-0.170	69.00	10.00
10	1.00	-0.170	68.00	10.00
11	1.00	0.000	66.00	10.00
12	1.00	-0.170	63.00	10.00
13	1.00	-0.170	61.00	10.00
14	1.00	-0.170	59.00	10.00
15	1.00	-0.170	57.00	10.00
16	1.00	-0.170	55.00	10.00
17	1.00	-0.170	43.00	10.00
18	1.00	-0.170	52.00	10.00
19	1.00	-0.170	50.00	10.00
20	1.00	-0.170	49.00	10.00
21	1.00	-0.170	47.00	10.00
22	1.00	-0.170	42.00	10.00
23	1.00	0.000	41.00	10.00
24	1.00	-0.170	36.00	10.00
25	1.00	-0.170	39.00	10.00
26	1.00	0.000	42.00	10.00
27	1.00	-0.170	35.00	10.00
28	1.00	-0.170	50.00	10.00
29	1.00	0.000	52.00	10.00
30	1.00	-0.170	43.00	10.00
31	1.00	0.000	53.00	10.00
32	1.00	-0.170	50.00	10.00
33	1.00	-0.170	43.00	10.00
34	1.00	0.000	40.00	10.00
35	1.00	-0.170	55.00	10.00
36	1.00	-0.170	42.00	10.00
37	1.00	-0.500	44.00	10.00
38	1.00	-0.170	46.00	10.00
39	1.00	0.000	47.00	10.00
40	1.00	-0.170	50.00	10.00
41	1.00	-0.170	53.00	10.00
42	1.00	-0.170	57.00	10.00
43	1.00	-0.170	50.00	10.00
44	1.00	0.000	55.00	10.00
45	1.00	-0.170	58.00	10.00
46	1.00	-0.170	41.00	10.00

Commercial Diameter Data

All pipes uPVC class 9

Pipe Dia. Bore (mm)	Hazen's Const	Unit Cost R/m
50.0	150.00000	14.20

Cost Summary

Diameter (mm)	Length (m)	Cost (1000 R)	Cum. Cost (1000 R)
50.0	2961.23	42.05	42.05
65.0	1280.77	25.26	67.31

Appendix 5.4 Source of cost data

The following items were costed from the sources below. All prices for May, 1998. VAT, transport and discounts inclusive.

1. Groundwater development costs: Water Systems Management, Pietersburg, SA.
2. Pipes, fittings, valves: Main Industries, Pietersburg, SA and National Trading; Company (NTC), Pietersburg, SA.
3. Reservoir: Averaged R/m3 price for concrete reservoirs constructed in Mvula projects in Mpumalanga.
4. Professional fees: DWAF/ECSA recommended rates for rural water supply projects.
5. O&M:
   - Connection costs: Prices from Main Industries, NTC, Kent Meters and local labour rates;
   - Staffing, administration and capacity building: estimated costs from author's experience and consultation with consultants;
   - Operation costs: based on expected performance of Lister engines.

Other information sourced from personal communication with: Mike Thompson (Tso-gang Water and Sanitation), Eric Harvey (Mvula Trust), Adie Vienings (DWAF) and Pierre Mouton (Water Systems Management).

Appendix 5.4 Cost of connections

Cost per standpipe

Item	Description	Unit	Qty	Rate	Total
Materials	75/63/50/40/35 x 1" (25mm) saddle	ea.	1	28.24	28.24
	25mm HDPE Cl 6	m	20	3.09	61.80
	160mm PVC + end cap	m	0.5	60.36	30.18
	3/4" GI pipe (standpipe) x 1000mm	ea.	1	12.02	12.02
	3/4" (20mm) GI pipe (standpipe) x 500mm	ea.	1	6.14	6.14
	Cement (OPC)	bags	2	22.19	44.38
	3/4" globe valve (stopcock)	ea.	1	40.54	40.54
	3/4" elbow	ea.	2	6.98	13.96
	3/4" brass tap (plain bibcock)	ea.	1	39.94	39.94
	3/4" nipple	ea.	1	2.00	2.00
	25 x 1" male adapter	ea.	1	10.57	10.57
	25 x 3/4" male adapter	ea.	1	10.57	10.57
	Drainage: 300mm cast iron grid	ea.	1	50.00	50.00
	- 90mm HDPE Cl 6	m	8	26.90	215.20
	- soakaway (within labour cost)	m^3	12	0.00	0.00
	Subtotal				565.54
	Total + VAT	VAT =	14%		644.72
Labour	semi-skilled	mandays	0.5	60.00	30.00
	unskilled	mandays	12	30.00	360.00
	Subtotal				390.00
	TOTAL				1,034.72

Cost per yard connection

Item	Description	Unit	Qty	Rate	Total
Materials	75/63/50/40/35 x 1/2" saddle	ea.	1	28.24	28.24
	16mm HDPE	m	90	1.64	147.60
	160mm PVC + end cap	m	0.5	60.36	30.18
	1/2" GI pipe x 1000mm	ea.	1	10.14	10.14
	1/2" GI pipe x 500mm	ea.	1	5.11	5.11
	Cement	bags	0.5	22.19	11.10
	1/2" globe valve (stopcock)	ea.	1	24.51	24.51
	1/2" (15mm) elbow	ea.	2	4.65	9.30
	1/2" threaded brass tap (hose bibcock)	ea.	1	26.26	26.26
	1/2" nipple	ea.	1	1.54	1.54
	16 x 1/2" male adapter	ea.	2	6.88	13.76
	1/2" Kent water meter	ea.	1	183.70	183.70
	Meter box + key	ea.	1	60.00	60.00
	Drainage: 200mm cast iron grid	ea.	1	35.00	35.00
	- 90mm HDPE Cl 6	m	5	26.90	134.50
	- soakaway (within labour cost)	m^3	6	0.00	0.00
	Subtotal				720.94
	Total + VAT	VAT =	14%		821.87
Labour	semi-skilled	mandays	0.5	60.00	30.00
	unskilled (pipework + yard standpipe)	mandays	3	30.00	90.00
	unskilled (trenching from mainline)	mandays	11	0.00	0.00
	Subtotal				120.00
	TOTAL				941.87

Cost per house (kitchen) connection

Item	Description	Unit	Qty	Rate	Total
Materials	75/63/50/40/35 x 1/2" saddle	ea.	1	28.24	28.24
	15mm HDPE	m	100	1.64	164.00
	1/2" GI pipe x 1500mm	ea.	1	15.09	15.09
	1/2" GI pipe x 500mm	ea.	2	5.11	10.22
	Cement	bags	1	22.19	22.19
	1/2" globe valve	ea.	1	24.51	24.51
	1/2" elbow	ea.	4	4.65	18.60
	1/2" threaded brass tap (hose bibcock)	ea.	1	26.26	26.26
	1/2" nipple	ea.	1	1.54	1.54
	15 x 1/2" male adapter	ea.	3	6.88	20.64
	1/2" Kent water meter	ea.	1	183.70	183.70
	Meter box	ea.	1	60.00	60.00
	Basin (stainless steel, 900x535mm)	ea.	1	288.88	288.88
	U-tube and drainage pipe (6m x 50mm dia.)	ea.	1	67.50	67.50
	- soakaway (within labour cost)	m^3	12	0.00	0.00
	Subtotal				931.37
	Total + VAT	VAT =	14%		1,061.76
Labour	semi-skilled	mandays	1	60.00	60.00
	unskilled (pipework + kitchen tap)	mandays	4	30.00	120.00
	unskilled (trenching from mainline)	mandays	12	0.00	0.00
	Subtotal				180.00
	TOTAL				1,241.76

Appendix 5.5 Costs for Scenario 1: All communal standpipes

Present population (1998) 1874
No of households 312
ALL PRICES INCLUDE VAT AT 14%

Capital Costs

Item	No. of holes	Quantity	Unit	Rate	Capital cost: Plant / contractor	Capital cost: Materials	Capital cost: Labour	Capital cost: TOTAL (R)	
1 Source development need (l/s) **2.2**									
(Assume water quality is adequate i.e. no treatment needed)									
Ground water development costs									
Drilling (estimated depths from experience in area)									
Drilling (165mm dia)	2	65	m	48	6,240			6,240	
Reaming (215mm dia)	1	35	m	75	2,625			2,625	
Casing (177mm)	1	35	m	95	3,325			3,325	
Development, sanitary seal & concrete, borehole cap	1	1	hole	800	800			800	
Traveling and set up costs	1	1	hole	1,000	1,000			1,000	
Testing (4 steps + 24hr CD + recovery)	1	1	hole	4,500	4,500			4,500	
Professional fees: siting, geophysics & water quality	1	1	hole	2,500	2,500			2,500	
Supervision	2	1	hole	3,600	7,200			7,200	
Reporting	1	1	hole	3,500	3,500			3,500	
Borehole equipment									
Mono pump - 80m static head, 2.5l/s	1	1	hole	7,500		7,500		7,500	
Pipework at borehole (steel rising main)	1	1	hole	4,500		4,500		4,500	
Diesel engine - Lister TS1	1	1	hole	12,000		12,000		12,000	
Pump house	1	1	hole	3,800		3,800		3,800	
Installation	1	1	hole	5,000	5,000			5,000	
Subtotal borehole								64,490	
Subtotal borehole - including VAT at 14%								73,519	
Pumping main: materials (uPVC 110 Cl 9)		730	m	41.95		30,624		30,624	
Labour		730	m	7.20			5,256	5,256	
Subtotal pumping main								35,880	
SUBTOTAL								100,370	100,370
2 Storage need (kl/d) **129**									
Reinforced concrete reservoir		150	m3	746	111,900			111,900	111,900
3 Distribution need (l/s) **6.3**									
Pipeline (designed on BRANCH)									
Materials u PVC pipe (63-110mm Cl 9)						148,890		148,890	
Fittings and valves @ 15%						22,334		22,334	
Labour		6993	m	7			50,350	50,350	
Subtotal								221,573	
Connections (standpipes)									
Materials		37	ea.	645		23,854		23,854	
Labour		37	ea.	390			14,430	14,430	
Subtotal								38,284	
SUBTOTAL								259,858	259,858
SUBTOTAL CAPITAL COSTS (exl. Prof. fees)					148,590	253,501	70,036		472,127
4 Professional costs									
Technical 12.50% of capital cost (<500,000)					59,016			59,016	
Social & training lump sum					50,000			50,000	
Committee / local government costs - admin., overheads etc.					10,000			10,000	
SUBTOTAL								119,016	
Subtotal + VAT 14%								135,678	135,678
TOTAL					284,268	253,501	70,036		**607,805**

Recurrent costs

Item	Quantity /month	Unit	Rate	Economic life (yrs)	Capital cost	CRF	Estimated cost: Annual	Estimated cost: R/month
1 Staffing, administration & capacity building								
Salaries:								
Water committee(chairperson, secretary & bookkeeper)	1.5	people/	750					1,125
Pump operators	1	month	750					750
Maintenance team	1		400					400
Water Bailiffs	0.2		400					80
Billing, collection etc. - standpipes (flat rate)	312	houses	1					312
- individual connections (metered rate)	0	houses	5					-
Transport	300	km	1.5					450
Capacity building	1	ea.	200					200
Administration & overheads	5%	%	3,317					166
2 Operation costs								-
Diesel for engines (estimation related to flow) (diesel priced at R2.05	1,968	m3/mon	0.5					984
Other (oil, etc.) (estimated % of power costs)	15%	%	984					148
3 Routine maintenance (spare parts etc.)								-
Tools	1		50					50
Source (borehole, pump, engine, pump house)	1		200					200
Reservoir	1		50					50
Distribution pipeline + pumping main	1		100					100
Standpipes	312		0.1					31
SUBTOTAL O & M COSTS								**5,046**
4 Depreciation (replacement costs) DF = 8%								
Source (borehole, pump, engine, pump house)				10	64,490	0.149	9,611	801
Reservoir				30	111,900	0.089	9,940	828
Distribution pipeline + pumping main				30	257,453	0.089	22,869	1,906
Standpipes				20	38,284	0.102	3,899	325
SUBTOTAL DEPRECIATION COSTS					472,127			**3,860**
TOTAL O & M + DEPRECIATION COSTS								**8,906**

Costs for Scenario 2: All yard connections

Present population (1998) 1874
No of households 312
ALL PRICES INCLUDE VAT AT 14%

Capital Costs

						Capital cost				
		No of	Quantity	Unit	Rate	Plant /	Materials	Labour	TOTAL	
		holes				contractor			(R)	
1	**Source development** need (l/s) **7.2**									
	(Assume water quality is adequate i.e. no treatment needed)									
	Ground water development costs									
	Drilling (estimated depths from experience in area)									
	Drilling (165mm dia)	2	65	m	48	6,240			6,240	
	Reaming (215mm dia)	1	35	m	75	2,625			2,625	
	Casing (177mm)	1	35	m	95	3,325			3,325	
	Development, sanitary seal & concrete, borehole cap	1	1	hole	800	800			800	
	Traveling and set up costs	1	1	hole	1,000	1,000			1,000	
	Testing (4 steps + 24hr CD + recovery)	1	1	hole	4,500	4,500			4,500	
	Professional fees: siting, geophysics & water quality	1	1	hole	2,500	2,500			2,500	
	Supervision	2	1	hole	3,600	7,200			7,200	
	Reporting	1	1	hole	3,500	3,500			3,500	
	Borehole equipment									
	Mono pump - 80m static head, 9 l/s	1	1	hole	16,000		16,000		16,000	
	Pipework at borehole (steel rising main)	1	1	hole	4,500		4,500		4,500	
	Diesel engine - Lister TS2	1	1	hole	22,000		22,000		22,000	
	Pump house	1	1	hole	3,800		3,800		3,800	
	Installation	1	1	hole	5,000	5,000			5,000	
	Subtotal borehole								82,990	
	Subtotal borehole - including VAT at 14%								94,609	
	Pumping main materials (uPVC 140mm Cl 9)		730	m	68.89		50,290		50,290	
	Labour		730	m	7.20			5,256	5,256	
	Subtotal pumping main								55,546	
	SUBTOTAL								150,154	150,154
2	**Storage** need (kl/d) **414**									
	Reinforced concrete reservoir		450	m3	746	335,700			335,700	335,700
3	**Distribution** need (l/s) **13.8**									
	Pipeline (designed on BRANCH - World Bank, 1991)									
	Materials u PVC pipe (O.D.63-140mm Cl 9)						224,890		224,890	
	Fittings and valves @ 15%						33,734		33,734	
	Labour		5584	m	7.2			40,205	40,205	
	Subtotal								298,828	
	Connections (yard)									
	Materials		312	ea.	821.87		256,696		256,696	
	Labour		312	ea.	120			37,480	37,480	
	Subtotal								294,176	
	SUBTOTAL (Distribution)								593,004	
	SUBTOTAL without connection costs (financed by households)								298,828	298,828
	SUBTOTAL CAPITAL COSTS (exl. Prof. fees)					335,700	565,609	82,941		784,683
4	**Professional costs**									
	Technical 10% of capital cost (>500,000; <1.5M)					78,468			78,468	
	Social & training lump sum					50,000			50,000	
	Committee / local government costs - admin., overheads etc.					10,000			10,000	
	SUBTOTAL								138,468	
	Subtotal + VAT 14%								157,854	157,854
	TOTAL					493,554	565,609	82,941		**942,536**

Recurrent Costs

	Item	Quantity	Unit	Rate	Economic	Capital	CRF	Estimated costs	
					life (yrs)	Cost		Annual	R/month
1	**Connection cost**								
	50% of connection cost up front	471							
	50% household loan over 5 yrs Interest	15%			5	471	0.298	140	12
2	**Staffing, administration & capacity building**								
	Salaries:								
	Water committee(chairperson, secretary & bookkeeper)	2	people/	750					1,500
	Pump operators	1	month	750					750
	Maintenance team	1		400					400
	Water Bailiffs	0.2		400					80
	Billing, collection etc. - standpipes (flat rate)	0	houses	1					-
	- individual connections (metered rate)	312	houses	5					1,562
	Transport	500	km	1.5					750
	Capacity building	2	ea.	200					400
	Administration & overheads	5%	%	5,442					272
2	**Operation costs**								
	Diesel for engines (estimation related to flow)	6,298	m3/mon	0.5					3,149
	Other (oil, etc.) (estimated % of power costs)	15%	%	3,149					472
3	**Routine maintenance (spare parts etc.)**								-
	Tools	1.5		50					75
	Source (borehole, pump, engine, pump house)	1		200					200
	Reservoir	1.5		50					75
	Distribution pipeline + pumping main	2		100					200
	Standpipes	0		1					-
	SUBTOTAL O & M COSTS								**9,885**
5	**Depreciation (replacement costs)** DF = 8%								
	Source (borehole, pump, engine, pump house)				10	94,609	0.149	14,099	1,175
	Reservoir				30	335,700	0.089	29,819	2,485
	Distribution pipeline + pumping main				30	354,374	0.089	31,478	2,623
	SUBTOTAL DEPRECIATION COSTS					784,683			**6,283**
	TOTAL O & M + DEPRECIATION COSTS								**16,168**

Costs for Scenario 3: All house (kitchen) connections

Present population (1998) 1874
No of households 312
ALL PRICES INCLUDE VAT AT 14%

Capital Costs

	No. of holes	Quantity	Unit	Rate	Capital cost: Plant / contractor	Materials	Labour	TOTAL (R)	
1 **Source development** need (l/s) 11.7									
(Assume water quality is adequate i.e. no treatment needed)									
Ground water development costs									
Drilling (estimated depths from experience in area)									
Drilling (165mm dia)	4	65	m	48	12,480			12,480	
Reaming (215mm dia)	2	35	m	75	5,250			5,250	
Casing (177mm)	2	35	m	95	6,650			6,650	
Development, sanitary seal & concrete, borehole cap	2	1	hole	800	1,600			1,600	
Traveling and set up costs	1	1	hole	1,000	1,000			1,000	
Testing (4 steps + 24hr CD + recovery)	2	1	hole	4,500	9,000			9,000	
Professional fees: siting, geophysics & water quality	2	1	hole	2,500	5,000			5,000	
Supervision	4	1	hole	3,600	14,400			14,400	
Reporting	1.5	1	hole	3,500	5,250			5,250	
Borehole equipment									
Mono pump - 80m static head, 6 l/s	2	1	hole	12,000		24,000		24,000	
Pipework at borehole (steel rising main)	2	1	hole	4,500		9,000		9,000	
Diesel engine - Lister TR1	2	1	hole	15,000		30,000		30,000	
Pump house	2	1	hole	3,800		7,600		7,600	
Installation	2	1	hole	5,000	10,000			10,000	
Subtotal borehole								141,230	
Subtotal borehole - including VAT at 14%								161,002	
Pumping main materials (uPVC 140mm Cl 9)		2,500	m	68.89		172,225		172,225	
Labour		2,500	m	7.20			18,000	18,000	
Subtotal pumping main								190,225	
SUBTOTAL								351,227	351,227
2 **Storage** need (kl/d) 672									
Reinforced concrete reservoir		700	m3	746	522,200			522,200	522,200
3 **Distribution** need (l/s) 23.0									
Pipeline (designed on BRANCH - World Bank, 1991)									
Materials u PVC pipe (O.D.75-160mm Cl 9)						325,150		325,150	
Fittings and valves @ 15%						48,773		48,773	
Labour		5584	m	7			40,205	40,205	
Subtotal								414,127	
Connections (kitchen)									
Materials		312	ea.	1,062		331,624		331,624	
Labour		312	ea.	180			56,220	56,220	
Subtotal								387,844	
SUBTOTAL								801,971	
SUBTOTAL without connection costs (financed by households)								414,127	414,127
SUBTOTAL CAPITAL COSTS (exl. Prof. fees)					522,200	877,771	114,425		1,287,555
4 **Professional costs**									
Technical 10% of capital cost (>500,000; <1.5M)					128,755			128,755	
Social & training lump sum					50,000			50,000	
Committee / local government costs - admin., overheads etc.					10,000			10,000	
SUBTOTAL								188,755	
Subtotal + VAT 14%								215,181	215,181
TOTAL					737,381	877,771	114,425		**1,502,736**

Recurrent costs

Item	Quantity	Unit	Rate	Economic life (yrs)	Capital Cost	CRF	Estimated costs: Annual	R/month
1 **Connection cost**								
50% of connection cost up front	621							
50% household loan over 5 yrs Interest	15%			5	621	0.298	185	15
2 **Staffing, administration & capacity building**								
Salaries:								
Water committee(chairperson, secretary & bookkeeper)	2	people/	750					1,500
Pump operators	2	month	750					1,500
Maintenance team	1		400					400
Water Bailiffs	0.2		400					80
Billing, collection etc. - standpipes (flat rate)	0	houses	1					-
- individual connections (metered rate)	312	houses	5					1,562
Transport	500	km	1.5					750
Capacity building	2	ea.	200					400
Administration & overheads	5%	%	6,192					310
2 **Operation costs**								
Diesel for engines (estimated kWhr related to flow)	10,234	m3/mon	0.5					5,117
Other (oil, etc.) (estimated % of power costs)	15%	%	5,117					768
3 **Routine maintenance (spare parts etc.)**								-
Tools	1.5		50					75
Source (borehole, pump, engine, pump house)	2		200					400
Reservoir	2		50					100
Distribution pipeline + pumping main	2		100					200
Standpipes	0		1					-
SUBTOTAL O & M COSTS								**13,161**
5 **Depreciation (replacement costs)** DF = 8%								
Source (borehole, pump, engine, pump house)				10	161,002	0.149	23,994	2,000
Reservoir				30	522,200	0.089	46,386	3,865
Distribution pipeline + pumping main				30	604,352	0.089	53,683	4,474
SUBTOTAL DEPRECIATION COSTS					1,287,555			**10,339**
TOTAL O & M + DEPRECIATION COSTS								**23,500**

Costs for Scenario 4: Mixed level of service

Present population (1998) 1874
No of households 312
ALL PRICES INCLUDE VAT AT 14%

Capital Costs

		No. of holes	Quantity	Unit	Rate	Capital cost: Plant / contractor	Materials	Labour	TOTAL (R)	
1	**Source development** need (l/s) 3.5									
	(Assume water quality is adequate i.e. no treatment needed)									
	Ground water development costs									
	Drilling (estimated depths from experience in area)									
	Drilling (165mm dia)	2	65	m	48	6,240			6,240	
	Reaming (215mm dia)	1	35	m	75	2,625			2,625	
	Casing (177mm)	1	35	m	95	3,325			3,325	
	Development, sanitary seal & concrete, borehole ca	1	1	hole	800	800			800	
	Travelling and set up costs	1	1	hole	1,000	1,000			1,000	
	Testing (4 steps + 24hr CD + recovery)	1	1	hole	4,500	4,500			4,500	
	Professional fees: siting, geophysics & water quality	1	1	hole	2,500	2,500			2,500	
	Supervision	2	1	hole	3,600	7,200			7,200	
	Reporting	1	1	hole	3,500	3,500			3,500	
	Borehole equipment									
	Mono pump - 80m static head,6 l/s	1	1	hole	12,000		12,000		12,000	
	Pipework at borehole (steel rising main)	1	1	hole	4,500		4,500		4,500	
	Diesel engine - Lister TR1	1	1	hole	15,000		15,000		15,000	
	Pump house	1	1	hole	3,800		3,800		3,800	
	Installation	1	1	hole	5,000	5,000			5,000	
	Subtotal borehole								71,990	
	Subtotal borehole - including VAT at 14%								82,069	
	Pumping main materials (uPVC 110mm Cl 9)		730	m	41.95		30,624		30,624	
	Labour		730	m	7.20			5,256	5,256	
	Subtotal pumping main								35,880	
	SUBTOTAL								117,948	117,948
2	**Storage** need (kl/d) 199									
	Reinforced concrete reservoir		200	m3	746	149,200			149,200	149,200
3	**Distribution** need (l/s) 6.6									
	Pipeline (designed on BRANCH - World Bank, 1991)									
	Materials u PVC pipe (O.D.63-110mm Cl 9)						149,480		149,480	
	Fittings and valves 15%						22,422		22,422	
	Labour		6993	m	7.2			50,350	50,350	
	Subtotal								222,252	
	Connections									
	Standpipe Materials		37	ea.	644.72		23,854		23,854	
	Labour		37	ea.	390.00			14,430	14,430	
	Yard Materials		47	ea.	821.87		38,504		38,504	
	Labour		47	ea.	120.00			5,622	5,622	
	House Materials		16	ea.	######		16,581		16,581	
	Labour		16	ea.	180.00			2,811	2,811	
	Subtotal								101,803	
	SUBTOTAL (Distribution)								324,055	
	SUBTOTAL without individual connections (incl. standpipes)								260,536	260,536
	SUBTOTAL CAPITAL COSTS (exl. Prof. fees)					149,200	281,466	78,469		527,684
4	**Professional costs**									
	Technical 10% of capital cost (>500,000; <1.5M)					52,768			52,768	
	Social & training lump sum					50,000			50,000	
	Committee / local government costs - admin., overheads etc.					10,000			10,000	
	SUBTOTAL								112,768	
	Subtotal + VAT 14%								128,556	128,556
	TOTAL					277,756	281,466	78,469		**656,240**

Recurrent costs

	Item	Quantity	Unit	Rate	Economic life (yrs)	Capital Cost	CRF	Estimated costs: Annual	R/month
1	**Connection costs**								
	Yard: 50% of connection cost up front	471							
	50% household loan over 5 yrs Interest	15%			5	471	0.298	140	12
	House: 50% of connection cost up front	621							
	50% household loan over 5 yrs Interest	15%			5	621	0.298	185	15
2	**Staffing, administration & capacity building**								
	Salaries:								
	Water committee(chairperson, secretary & bookkeeper)	2	people/	750					1,500
	Pump operators	2	month	750					1,500
	Maintenance team	1		400					400
	Water Bailiffs	0.2		400					80
	Billing, collection etc. - standpipes (flat rate)	250	houses	1					250
	- individual connections (metered rate)	62	houses	5					312
	Transport	500	km	1.5					750
	Capacity building	2	ea.	200					400
	Administration & overheads	5%	%	5,192					260
2	**Operation costs**								
	Diesel for engines (estimated kWhr related to flow)	3,031	m3/mor	0.5					1,515
	Other (oil, etc.) (estimated % of power costs)	15%	%	1,515					227
3	**Routine maintenance (spare parts etc.)**								-
	Tools	1.5		50					75
	Source (borehole, pump, engine, pump house)	1		200					200
	Reservoir	1		50					50
	Distribution pipeline + pumping main	1		100					100
	Standpipes	250		0.1					25
	SUBTOTAL O & M COSTS								**7,645**
5	**Depreciation (replacement c** DF = 8%								
	Source (borehole, pump, engine, pump house)				10	82,069	0.149	12,231	1,019
	Reservoir				30	149,200	0.089	13,253	1,104
	Distribution pipeline + pumping main				30	258,131	0.089	22,929	1,911
	Standpipes				20	38,284	0.102	3,899	325
	SUBTOTAL DEPRECIATION COSTS					527,684			**4,359**
	TOTAL O & M + DEPRECIATION COSTS								**12,004**

Costs for Scenario 5: Mixed level of service

Present population (1998) 1874
No of households 312
ALL PRICES INCLUDE VAT AT 14%

Capital Costs

		No. of holes	Quantity	Unit	Rate	Capital cost: Plant / contractor	Materials	Labour	TOTAL (R)	
1	**Source development** need (l/s) 5.4									
	(Assume water quality is adequate i.e. no treatment needed)									
	Ground water development costs									
	Drilling (estimated depths from experience in area)									
	Drilling (165mm dia)	2	65	m	48	6,240			6,240	
	Reaming (215mm dia)	1	35	m	75	2,625			2,625	
	Casing (177mm)	1	35	m	95	3,325			3,325	
	Development, sanitary seal & concrete, borehole ca	1	1	hole	800	800			800	
	Traveling and set up costs	1	1	hole	1,000	1,000			1,000	
	Testing (4 steps + 24hr CD + recovery)	1	1	hole	4,500	4,500			4,500	
	Professional fees: siting, geophysics & water quality	1	1	hole	2,500	2,500			2,500	
	Supervision	2	1	hole	3,600	7,200			7,200	
	Reporting	1	1	hole	3,500	3,500			3,500	
	Borehole equipment									
	Mono pump - 80m static head, 6 l/s	1	1	hole	12,000		12,000		12,000	
	Pipework at borehole (steel rising main)	1	1	hole	4,500		4,500		4,500	
	Diesel engine - Lister TR1	1	1	hole	15,000		15,000		15,000	
	Pump house	1	1	hole	3,800		3,800		3,800	
	Installation	1	1	hole	5,000	5,000			5,000	
	Subtotal borehole								71,990	
	Subtotal borehole - including VAT at 14%								82,069	
	Pumping main materials (uPVC 140mm Cl 9)		730	m	68.89		50,290		50,290	
	Labour		730	m	7.20			5,256	5,256	
	Subtotal pumping main								55,546	
	SUBTOTAL								137,614	137,614
2	**Storage** need (kl/d) 310									
	Reinforced concrete reservoir		350	m3	746	261,100			261,100	261,100
3	**Distribution** need (l/s) 11.0									
	Pipeline (designed on BRANCH - World Bank, 1991)									
	Materials u PVC pipe (O.D.63-140mm Cl 9)						198,880		198,880	
	Fittings and valves 15%						29,832		29,832	
	Labour		6993	m	7.2			50,350	50,350	
	Subtotal								279,062	
	Connections									
	Standpipe Materials		37	ea.	644.72		23,854		23,854	
	Labour		37	ea.	390.00			14,430	14,430	
	Yard Materials		109	ea.	821.87		89,844		89,844	
	Labour		109	ea.	120.00			13,118	13,118	
	House Materials		47	ea.	1,061.76		49,744		49,744	
	Labour		47	ea.	180.00			8,433	8,433	
	Subtotal								199,423	
	SUBTOTAL (Distribution)								478,484	
	SUBTOTAL without individual connections (incl. standpipes)								317,346	317,346
	SUBTOTAL CAPITAL COSTS (exl. Prof. fees)					261,100	442,443	91,587		716,060
4	**Professional costs**									
	Technical 10% of capital cost (>500,000; <1.5M)					71,606			71,606	
	Social & training lump sum					50,000			50,000	
	Committee / local government costs - admin., overheads etc.					10,000			10,000	
	SUBTOTAL								131,606	
	Subtotal + VAT 14%								150,031	150,031
	TOTAL					411,131	442,443	91,587		**866,091**

Recurrent costs

	Item	Quantity	Unit	Rate	Economic life (yrs)	Capital Cost	CRF	Estimated costs: Annual	R/month
1	**Connection cost**								
	Yard: 50% of connection cost up front	471							
	50% household loan over 5 yrs Interest	15%			5	471	0.298	140	12
	House: 50% of connection cost up front	621							
	50% household loan over 5 yrs Interest	15%			5	621	0.298	185	15
2	**Staffing, administration & capacity building**								
	Salaries:								
	Water committee(chairperson, secretary & bookkeeper)	2	people/	750					1,500
	Pump operators	2	month	750					1,500
	Maintenance team	1		400					400
	Water Bailiffs	0.2		400					80
	Billing, collection etc. - standpipes (flat rate)	156	houses	1					156
	- individual connections (metered rate)	156	houses	5					781
	Transport	500	km	1.5					750
	Capacity building	2	ea.	200					400
	Administration & overheads	5%	%	5,567					278
2	**Operation costs**								
	Diesel for engines (estimated kWhr related to flow)	4,724	m3/mor	0.5					2,362
	Other (oil, etc.) (estimated % of power costs)	15%	%	2,362					354
3	**Routine maintenance (spare parts etc.)**								-
	Tools	1.5		50					75
	Source (borehole, pump, engine, pump house)	1		200					200
	Reservoir	1.5		50					75
	Distribution pipeline + pumping main	2		100					200
	Standpipes	156		0.1					16
	SUBTOTAL O & M COSTS								**9,127**
5	**Depreciation (replacement c** DF = 8%								
	Source (borehole, pump, engine, pump house)				10	82,069	0.149	12,231	1,019
	Reservoir				30	261,100	0.089	23,193	1,933
	Distribution pipeline + pumping main				30	334,607	0.089	29,722	2,477
	Standpipes				20	38,284	0.102	3,899	325
	SUBTOTAL DEPRECIATION COSTS					716,060			**5,754**
	TOTAL O & M + DEPRECIATION COSTS								**14,881**

Costs for Scenario 6: Mixed level of service

Present population (1998) 1874
No of households 312
ALL PRICES INCLUDE VAT AT 14%

Capital Costs

	Item	No. of holes	Quantity	Unit	Rate	Capital cost: Plant / contractor	Materials	Labour	TOTAL (R)	
1	**Source development** need (l/s) 7.5									
	(Assume water quality is adequate i.e. no treatment needed)									
	Ground water development costs									
	Drilling (estimated depths from experience in area)									
	Drilling (165mm dia)	2	65	m	48	6,240			6,240	
	Reaming (215mm dia)	1	35	m	75	2,625			2,625	
	Casing (177mm)	1	35	m	95	3,325			3,325	
	Development, sanitary seal & concrete, borehole ca	1	1	hole	800	800			800	
	Traveling and set up costs	1	1	hole	1,000	1,000			1,000	
	Testing (4 steps + 24hr CD + recovery)	1	1	hole	4,500	4,500			4,500	
	Professional fees: siting, geophysics & water quality	1	1	hole	2,500	2,500			2,500	
	Supervision	2	1	hole	3,600	7,200			7,200	
	Reporting	1	1	hole	3,500	3,500			3,500	
	Borehole equipment									
	Mono pump - 80m static head, 9 l/s	1	1	hole	16,000		16,000		16,000	
	Pipework at borehole (steel rising main)	1	1	hole	4,500		4,500		4,500	
	Diesel engine - Lister TS2	1	1	hole	22,000		22,000		22,000	
	Pump house	1	1	hole	3,800		3,800		3,800	
	Installation	1	1	hole	5,000	5,000			5,000	
	Subtotal borehole								82,990	
	Subtotal borehole - including VAT at 14%								94,609	
	Pumping main materials (uPVC 160mm Cl 9)		730	m	86.22		62,941		62,941	
	Labour		730	m	7.20			5,256	5,256	
	Subtotal pumping main								68,197	
	SUBTOTAL								162,805	162,805
2	**Storage** need (kl/d) 435									
	Reinforced concrete reservoir		450	m3	746	335,700			335,700	335,700
3	**Distribution** need (l/s) 15.1									
	Pipeline (designed on BRANCH - World Bank, 1991)									
	Materials u PVC pipe (O.D.63-160mm Cl 9)						244,270		244,270	
	Fittings and valves 15%						36,641		36,641	
	Labour		6993	m	7.2			50,350	50,350	
	Subtotal								331,260	
	Connections									
	Standpipe Materials		37	ea.	644.72		23,854		23,854	
	Labour		37	ea.	390.00			14,430	14,430	
	Yard Materials		156	ea.	821.87		128,348		128,348	
	Labour		156	ea.	120.00			18,740	18,740	
	House Materials		94	ea.	1,061.76		99,487		99,487	
	Labour		94	ea.	180.00			16,866	16,866	
	Subtotal								301,726	
	SUBTOTAL (Distribution)								632,986	
	SUBTOTAL without individual connections (incl. standpipes)								369,545	369,545
	SUBTOTAL CAPITAL COSTS (exl. Prof. fees)					335,700	595,541	105,642		868,050
4	**Professional costs**									
	Technical 10% of capital cost (>500,000; <1.5M)					86,805			86,805	
	Social & training lump sum					50,000			50,000	
	Committee / local government costs - admin., overheads etc.					10,000			10,000	
	SUBTOTAL								146,805	
	Subtotal + VAT 14%								167,358	167,358
	TOTAL					503,058	595,541	105,642		**1,035,407**

Recurrent costs

	Item	Quantity	Unit	Rate	Economic life (yrs)	Capital Cost	CRF	Estimated costs: Annual	R/month
1	**Connection cost**								
	Yard: 50% of connection cost up front	471							
	50% household loan over 5 yrs Interest	15%			5	471	0.298	140	12
	House: 50% of connection cost up front	621							
	50% household loan over 5 yrs Interest	15%			5	621	0.298	185	15
2	**Staffing, administration & capacity building**								
	Salaries:								
	Water committee(chairperson, secretary & bookkeeper)	2	people/	750					1,500
	Pump operators	2	month	750					1,500
	Maintenance team	1		400					400
	Water Bailiffs	0.2		400					80
	Billing, collection etc. - standpipes (flat rate)	62	houses	1					62
	- individual connections (metered rate)	250	houses	5					1,249
	Transport	500	km	1.5					750
	Capacity building	2	ea.	200					400
	Administration & overheads	5%	%	5,942					297
2	**Operation costs**								
	Diesel for engines (estimated kWhr related to flow)	6,613	m3/mor	0.5					3,307
	Other (oil, etc.) (estimated % of power costs)	15%	%	3,307					496
3	**Routine maintenance (spare parts etc.)**								-
	Tools	1.5		50					75
	Source (borehole, pump, engine, pump house)	1		200					200
	Reservoir	1.5		50					75
	Distribution pipeline + pumping main	2		100					200
	Standpipes	62		0.1					6
	SUBTOTAL O & M COSTS								**10,598**
5	**Depreciation (replacement c** DF = 8%								
	Source (borehole, pump, engine, pump house)				10	94,609	0.149	14,099	1,175
	Reservoir				30	335,700	0.089	29,819	2,485
	Distribution pipeline + pumping main				30	399,457	0.089	35,483	2,957
	Standpipes				20	38,284	0.102	3,899	325
	SUBTOTAL DEPRECIATION COSTS					868,050			**6,942**
	TOTAL O & M + DEPRECIATION COSTS								**17,539**

Appendix 5.6 Summary of costs - base year

Present population (1998)	1874	All prices in SA Rands for May 1998
No of households	312	May, 1998:
		£(UK) 1 = R 8.30
		$(US) 1 = R 5.00

Connection costs:

	Up front payment	Monthly payment (over 5 years)
Yard connection:	471	12
House connection:	621	15

	Capital cost			O & M costs				Unit operating costs					
				O & M		O & M + depreciation		Water produced		Water consumed (less UFW)		Unit costs	
				R/mon	R/mon/	R/mon	R/mon/		average		average	O & M	O & M + deprec.
	(R)		R/capita		house		house	m3/d	l/c/d		l/c/d	R/m3	R/m3
Scenario 1: All communal standpipes													
1 Source development	100,370	17%											
2 Storage	111,900	18%											
3 Distribution	259,858	43%											
4 Professional	135,678	22%											
TOTAL	607,805	100%	324	5,046	16	8,906	29	65	35	54	29	2.56	4.52
Scenario 2: All yard connections													
1 Source development	150,154	16%											
2 Storage	335,700	36%											
3 Distribution	298,828	32%											
4 Professional costs	157,854	17%											
TOTAL	942,536	100%	503	9,885	32	#####	52	207	110	172	92	1.57	2.57
Difference between scenarios 2 and 1	334,731	36%	179										
Scenario 3: All house connections													
1 Source development	351,227	23%											
2 Storage	522,200	35%											
3 Distribution	414,127	28%											
4 Professional costs	215,181	14%											
TOTAL	1,502,736	100%	802	#####	42	#####	75	336	179	280	150	1.29	2.30
Difference between scenarios 3 and 1	894,931	60%	478										
Scenario 4: Mixed level of service													
1 Source development	117,948	18%											
2 Storage	149,200	23%											
3 Distribution	260,536	40%											
4 Professional costs	128,556	20%											
TOTAL	656,240	100%	350	7,645	24	#####	38	100	53	83	44	2.52	3.96
Difference between scenarios 4 and 1	48,435	7%	26										
Scenario 5: Mixed level of service													
1 Source development	137,614	16%											
2 Storage	261,100	30%											
3 Distribution	317,346	37%											
4 Professional costs	150,031	17%											
TOTAL	866,091	100%	462	9,127	29	#####	48	155	83	129	69	1.93	3.15
Difference between scenarios 5 and 1	258,286	30%	138										
Scenario 6: Mixed level of service													
1 Source development	162,805	16%											
2 Storage	335,700	32%											
3 Distribution	369,545	36%											
4 Professional costs	167,358	16%											
TOTAL	1,035,407	100%	553	#####	34	#####	56	217	116	181	97	1.60	2.65
Difference between scenarios 6 and 1	427,602	41%	228										
Average													
1 Source development	-	18%											
2 Storage	-	29%											
3 Distribution	1,035,407	36%											
4 Professional costs	-	18%											
TOTAL	1,035,407	100%	553	-	-	-	-	3			1	0.00	0.00

Appendix 5.7 Tariffs to break-even

Assumptions:

1	All consumers pay same metered rate
2	UFW is charged to consumer

Cash Flow

Year	Revenue									Cost							Net revenue	
										Capital cost of scenario 1	Loan repay over 20 yrs at 13%	Capital difference	O & M	Replace ment	O & M + replace.	Total	(Revenue - cost)	
	Standpipes		Individual connections		Institut.	UFW	Total	Tariff	Total									
												*1	*2	*3				
	no.	m3/d	no.	m3/d	m3/d	m3/d	m3/d	R/m3									Annual	Cumulative
1	250	37	62	35	11	17	83	9.77	295,854	607,805	86,523	70,650	82,580	56,100	138,680	295,854	-	-
2	253	38	67	37	11	17	86	7.55	237,434		86,523	9,238	84,583	57,090	141,673	237,434	-	-
3	257	39	71	39	12	18	90	7.37	241,036		86,523	9,849	86,609	58,056	144,664	241,036	-	-
4	260	39	76	42	12	19	93	7.19	244,678		86,523	10,509	88,654	58,991	147,646	244,678	-	-
5	264	40	81	45	13	19	97	7.01	248,357		86,523	11,224	90,718	59,892	150,609	248,357	- 0	- 0
6	267	40	86	48	13	20	101	6.84	252,070		86,523	11,999	92,796	60,752	153,547	252,070	-	- 0
7	270	41	92	51	14	21	105	6.67	255,814		86,523	12,839	94,886	61,566	156,452	255,814	-	- 0
8	273	41	98	54	14	22	109	6.49	259,588		86,523	13,751	96,986	62,329	159,314	259,588	0	-
9	276	41	104	58	15	23	114	6.32	263,392		86,523	14,741	99,093	63,035	162,128	263,392	-	-
10	279	42	111	62	16	24	119	6.15	267,227		86,523	15,817	101,207	63,679	164,886	267,227	-	-
11	281	42	118	66	16	25	124	5.99	271,097		86,523	16,989	103,326	64,258	167,584	271,097	-	-
12	283	42	126	70	17	26	129	5.82	275,008		86,523	18,265	105,452	64,768	170,220	275,008	-	-
13	285	43	134	75	18	27	135	5.66	278,973		86,523	19,656	107,586	65,208	172,794	278,973	-	-
14	287	43	143	79	18	28	141	5.50	283,007		86,523	21,174	109,733	65,578	175,310	283,007	-	-
15	288	43	153	85	19	29	147	5.34	287,136		86,523	22,831	111,900	65,881	177,782	287,136	-	-
16	289	43	163	90	20	31	154	5.19	291,392		86,523	24,643	114,100	66,125	180,226	291,392	-	-
17	290	43	174	96	21	32	161	5.04	295,820		86,523	26,625	116,349	66,322	182,671	295,820	- 0	- 0
18	290	43	185	103	22	34	168	4.90	300,479		86,523	28,796	118,669	66,490	185,160	300,479	-	- 0
19	289	43	197	109	23	35	176	4.76	305,448		86,523	31,176	121,093	66,656	187,749	305,448	-	- 0
20	289	43	210	117	24	37	184	4.63	310,826		86,523	33,786	123,661	66,856	190,517	310,826	-	- 0
												353,908		1,259,633				

1 Capital cost derived from best fit curve of capital cost vs consumption: Capital cost (R) =4.773(water produced(m3/d))^2 + 1,390.6*(production) + 492,932
Note: this capital investment is an averaged figure corresponding to the scale of infrastructure needed to meet the demand consumption,
in reality, this investment would be more 'lumpy' as various capital items needed upgrading

*2 Based on marginal O & M costs derived from best fit curve of cost vs consumption data: O & M cost (R/m3) = 0.00002(production (m3/d))^2 - 0.0125(production) + 3.3486

3 Based on marginal depreciation costs: Depreciation (R/m3) = .00002(production(m3/d))^2 - 0.0123*(production) + 2.5698

Appendix 5.8 Average Incremental Costs - scenario 4

Year	Discount factor 8%	Capital cost of communal standpipe supply (scenario 1) *4: Full repayment of loan (R)	20 years at (R)	Interest 13%	Capital cost of scenario 4: *1 (R)	Incremental Increase (R)	PV (R)	Capital cost difference between scenario 4 & scenario 1 (R)	Incremental Increase (R)	PV (R)	Replacement costs (based on depreciation): *2 R/m3	R/yr.	PV R/yr.	O & M costs: *3 R/m3	(R/yr.)	PV (R/yr.)	Water produced Total (+ UFW): m3/day	(m3/yr)	Water Consumed Total domestic & Institutional: m3/day	(m3/yr)	PV 8% (m3/yr)
1	0.926	607,805	86,523	80,114	678,455	678,455	628,200	70,650	70,650	65,417	1.54	56,100	51,945	2.27	82,580	76,463	99	36,328	83	30,273	28,031
2	0.857		86,523	74,180	687,693	9,238	7,920	79,888	9,238	7,920	1.51	57,090	48,946	2.24	84,583	72,516	103	37,758	86	31,465	26,976
3	0.794		86,523	68,685	697,542	9,849	7,818	89,737	9,849	7,818	1.48	58,056	46,087	2.21	86,609	68,753	107	39,259	90	32,716	25,971
4	0.735		86,523	63,597	708,051	10,509	7,725	100,246	10,509	7,725	1.44	58,991	43,360	2.17	88,654	65,164	112	40,834	93	34,028	25,012
5	0.681		86,523	58,886	719,275	11,224	7,639	111,470	11,224	7,639	1.41	59,892	40,761	2.14	90,718	61,741	116	42,487	97	35,406	24,097
6	0.630		86,523	54,524	731,274	11,999	7,561	123,469	11,999	7,561	1.37	60,752	38,284	2.10	92,796	58,477	121	44,224	101	36,853	23,224
7	0.583		86,523	50,486	744,113	12,839	7,491	136,308	12,839	7,491	1.34	61,566	35,923	2.06	94,886	55,365	126	46,048	105	38,374	22,391
8	0.540		86,523	46,746	757,864	13,751	7,429	150,059	13,751	7,429	1.30	62,329	33,674	2.02	96,986	52,398	131	47,966	109	39,971	21,595
9	0.500		86,523	43,283	772,605	14,741	7,374	164,800	14,741	7,374	1.26	63,035	31,533	1.98	99,093	49,571	137	49,982	114	41,652	20,836
10	0.463		86,523	40,077	788,422	15,817	7,327	180,617	15,817	7,327	1.22	63,679	29,496	1.94	101,207	46,878	143	52,102	119	43,419	20,111
11	0.429		86,523	37,108	805,411	16,989	7,286	197,606	16,989	7,286	1.18	64,258	27,559	1.90	103,326	44,315	149	54,333	124	45,278	19,419
12	0.397		86,523	34,360	823,676	18,265	7,253	215,871	18,265	7,253	1.14	64,768	25,720	1.86	105,452	41,876	155	56,681	129	47,234	18,757
13	0.368		86,523	31,814	843,332	19,656	7,227	235,526	19,656	7,227	1.10	65,208	23,977	1.82	107,586	39,559	162	59,153	135	49,294	18,125
14	0.340		86,523	29,458	864,505	21,174	7,209	256,700	21,174	7,209	1.06	65,578	22,327	1.78	109,733	37,360	169	61,756	141	51,464	17,521
15	0.315		86,523	27,276	887,336	22,831	7,197	279,531	22,831	7,197	1.02	65,881	20,769	1.73	111,900	35,276	177	64,499	147	53,749	16,944
16	0.292		86,523	25,255	911,979	24,643	7,193	304,174	24,643	7,193	0.98	66,125	19,301	1.69	114,100	33,305	185	67,390	154	56,158	16,392
17	0.270		86,523	23,385	938,605	26,625	7,196	330,800	26,625	7,196	0.94	66,322	17,925	1.65	116,349	31,445	193	70,436	161	58,697	15,864
18	0.250		86,523	21,652	967,401	28,796	7,206	359,596	28,796	7,206	0.90	66,490	16,639	1.61	118,669	29,697	202	73,650	168	61,375	15,359
19	0.232		86,523	20,049	998,577	31,176	7,224	390,772	31,176	7,224	0.87	66,656	15,445	1.57	121,093	28,059	211	77,039	176	64,199	14,876
20	0.215		86,523	18,563	1,032,363	33,786	7,249	424,558	33,786	7,249	0.83	66,856	14,344	1.53	123,661	26,531	221	80,615	184	67,179	14,413
Total			1,730,467	849,499			768,725			205,942			604,015			954,749					405,913

Average Incremental Cost (AIC) = Present Value of Costs / PV of Water Consumed

AIC (O & M)	**R 954,749 /**	**405,913 m3 =**		**R 2.35 /m3**
AIC (replacement)	**R 604,015 /**	**405,913 m3 =**	**R 1.49 /m3**	
AIC (O & M + replacement)				**R 3.84 /m3**
AIC (capital difference)	**R 205,942 /**	**405,913 m3 =**	**R 0.51 /m3**	
AIC (O & M + replace + capital difference)				**R 4.35 /m3**
AIC (capital cost of communal standpipe supply + interest)	**R 849,499 /**	**405,913 m3 =**	**R 2.09 /m3**	
AIC (O & M + replace + full capital redemption)		**m3 =**		**R 6.44 /m3**

1 Capital cost derived from best fit curve of capital cost vs consumption: Capital cost (R) =4.773(water produced(m3/d))^2 + 1,390.6*(production) + 492,932
Note: this capital investment is an averaged figure corresponding to the scale of infrastructure needed to meet the demand consumption,
in reality, this investment would be more 'lumpy' as various capital items needed upgrading

*2 Based on unit costs of replacement cost vs consumption:
Unit cost (R/m3) = .00002*(production(m3/d))^2 - 0.0123*(production) + 2.5698

*3 Unit costs derived from best fit curve of cost vs consumption data
O & M cost (R/m3) = 0.00002(production (m3/d))^2 - 0.0125(production) + 3.3486

*4 Repayment of principle loan + interest set on Capital Recovery Factor at 13% (consistent with PDG, 1996) over 20 years.

Average Incremental Costs - Scenario 5

Year	Discount	**Capital cost**			**Capital cost**			**Capital cost difference**			**Replacement costs**			**O & M costs**			Water		**Water**		
	factor	of communal			of scenario 5			between scenario 5 &			(based on depreciation)						produced		**Consumed**		
		standpipe supply						scenario 1									Total		Total		PV
		(scenario 1) *4				Incre-			Incre-								(+ UFW)		domestic		
	8%	Full repayment of loan		Interest	*1	mental	PV		mental	PV	*2		PV	*3		PV			&		8%
		20	years at	13%		Increase			Increase										Institutional		
		R	R		R	R	R	R	R	R	R/m3	R/yr.	R/yr.	R/m3	(R/yr)	(R/yr)	m3/day	(m3/yr)	m3/day	(m3/yr)	(m3/yr)
1	0.926	607,805	86,523	80,114	823,151	823,151	762,177	215,346	215,346	199,394	1.14	64,755	59,958	1.86	105,393	97,586	155	56,614	129	47,179	43,684
2	0.857		86,523	74,180	845,188	22,037	18,893	237,383	22,037	18,893	1.10	65,244	55,936	1.81	107,780	92,404	163	59,384	135	49,486	42,427
3	0.794		86,523	68,685	869,084	23,896	18,969	261,279	23,896	18,969	1.05	65,646	52,112	1.77	110,179	87,463	171	62,312	142	51,926	41,221
4	0.735		86,523	63,597	895,022	25,938	19,065	287,217	25,938	19,065	1.01	65,965	48,487	1.72	112,600	82,765	179	65,408	149	54,507	40,064
5	0.681		86,523	58,886	923,206	28,184	19,182	315,401	28,184	19,182	0.96	66,215	45,065	1.68	115,062	78,310	188	68,684	157	57,236	38,954
6	0.630		86,523	54,524	953,862	30,656	19,318	346,057	30,656	19,318	0.92	66,415	41,853	1.63	117,590	74,102	198	72,149	165	60,124	37,888
7	0.583		86,523	50,486	987,241	33,379	19,476	379,436	33,379	19,476	0.88	66,596	38,858	1.59	120,220	70,147	208	75,817	173	63,181	36,865
8	0.540		86,523	46,746	1,023,623	36,382	19,656	415,818	36,382	19,656	0.84	66,800	36,090	1.54	123,000	66,453	218	79,699	182	66,416	35,882
9	0.500		86,523	43,283	1,063,319	39,696	19,858	455,514	39,696	19,858	0.80	67,088	33,561	1.50	125,999	63,031	229	83,809	191	69,841	34,938
10	0.463		86,523	40,077	1,106,675	43,356	20,082	498,870	43,356	20,082	0.77	67,543	31,286	1.47	129,303	59,892	241	88,163	201	73,469	34,030
11	0.429		86,523	37,108	1,154,078	47,403	20,330	546,273	47,403	20,330	0.74	68,274	29,281	1.43	133,030	57,054	254	92,773	212	77,311	33,157
12	0.397		86,523	34,360	1,205,959	51,881	20,603	598,154	51,881	20,603	0.71	69,423	27,569	1.41	137,327	54,535	267	97,658	223	81,382	32,318
13	0.368		86,523	31,814	1,262,798	56,840	20,900	654,993	56,840	20,900	0.69	71,177	26,172	1.38	142,389	52,356	282	102,835	235	85,696	31,510
14	0.340		86,523	29,458	1,325,134	62,336	21,223	717,329	62,336	21,223	0.68	73,774	25,117	1.37	148,460	50,545	297	108,321	247	90,268	30,733
15	0.315		86,523	27,276	1,393,566	68,432	21,573	785,761	68,432	21,573	0.68	77,519	24,437	1.37	155,851	49,131	312	114,137	260	95,114	29,984
16	0.292		86,523	25,255	1,468,766	75,200	21,950	860,961	75,200	21,950	0.69	82,798	24,168	1.37	164,957	48,149	329	120,304	274	100,253	29,263
17	0.270		86,523	23,385	1,551,486	82,719	22,356	943,680	82,719	22,356	0.71	90,099	24,351	1.39	176,269	47,640	347	126,843	289	105,702	28,568
18	0.250		86,523	21,652	1,642,565	91,080	22,793	1,034,760	91,080	22,793	0.75	100,032	25,033	1.42	190,406	47,649	366	133,779	305	111,482	27,898
19	0.232		86,523	20,049	1,742,948	100,382	23,260	1,135,142	100,382	23,260	0.80	113,363	26,268	1.47	208,139	48,228	386	141,137	322	117,614	27,253
20	0.215		86,523	18,563	1,853,688	110,741	23,759	1,245,883	110,741	23,759	0.88	131,042	28,115	1.55	230,423	49,437	408	148,943	340	124,119	26,630
Total			1,730,467	849,499			1,155,424			592,641			703,716			1,276,876					683,268

Average Incremental Cost (AIC) = Present Value of Costs / PV of Water Consumed				
AIC (O & M)	**R 1,276,876 /**	**683,268**	**m3 =**	**R 1.87 /m3**
AIC (replacement)	**R 703,716 /**	**683,268**	**m3 =**	**R 1.03 /m3**
AIC (O & M + replacement)				**R 2.90 /m3**
AIC (capital difference)	**R 592,641 /**	**683,268**	**m3 =**	**R 0.87 /m3**
AIC (O & M + replace + capital difference)				**R 3.77 /m3**
AIC (capital cost of communal standpipe supply + interest)	**R 849,499 /**	**683,268**	**m3 =**	**R 1.24 /m3**
AIC (O & M + replace + full capital redemption)			**m3 =**	**R 5.01 /m3**

1 Capital cost derived from best fit curve of capital cost vs consumption: Capital cost (R) =4.773(water produced(m3/d))^2 + 1,390.6*(production) + 492,932
Note: this capital investment is an averaged figure corresponding to the scale of infrastructure needed to meet the demand consumption,
in reality, this investment would be more 'lumpy' as various capital items needed upgrading

*2 Based on unit costs of replacement cost vs consumption:
Unit cost (R/m3) = .00002*(production(m3/d))^2 - 0.0123*(production) + 2.5698

*3 Unit costs derived from best fit curve of cost vs consumption data
O & M cost (R/m3) = 0.00002(production (m3/d))^2 - 0.0125(production) + 3.3486

*4 Repayment of principle loan + interest set on Capital Recovery Factor at 13% (consistent with PDG, 1996) over 20 years.

Average Incremental Costs - Scenario 6

Year	Discount	Capital cost			Capital cost			Capital cost difference			Replacement costs			O & M costs			Water		Water		
	factor	of communal			of scenario 6			between scenario 6 &			(based on depreciation)						produced		Consumed		
		standpipe supply						scenario 1									Total		Total		PV
		(scenario 1) *4				Incre-			Incre-								(+ UFW)		domestic		
	8%	Full repayment of loan		Interest	*1	mental	PV		mental	PV	*2		PV	*3		PV			&		8%
		20	years at	13%		Increase			Increase										Institutional		
		R	R		R	R	R	R	R	R	R/m3	R/yr.	R/yr.	R/m3	(R/yr)	(R/yr)	m3/day	(m3/yr)	m3/day	(m3/yr)	(m3/yr)
1	0.926	######	86,523	80,114	1,019,456	1,019,456	943,941	411,651	411,651	381,158	0.84	66,774	61,828	1.55	122,684	113,597	217	79,260	181	66,050	61,157
2	0.857		86,523	74,180	1,060,524	41,068	35,209	452,718	41,068	35,209	0.80	67,065	57,497	1.51	125,787	107,842	229	83,524	191	69,603	59,674
3	0.794		86,523	68,685	1,105,490	44,966	35,696	497,685	44,966	35,696	0.77	67,528	53,606	1.47	129,212	102,573	241	88,045	201	73,371	58,244
4	0.735		86,523	63,597	1,154,776	49,286	36,227	546,971	49,286	36,227	0.74	68,287	50,193	1.43	133,086	97,822	254	92,840	212	77,367	56,867
5	0.681		86,523	58,886	1,208,852	54,076	36,803	601,046	54,076	36,803	0.71	69,499	47,300	1.40	137,575	93,631	268	97,926	223	81,605	55,539
6	0.630		86,523	54,524	1,268,243	59,391	37,426	660,438	59,391	37,426	0.69	71,374	44,978	1.38	142,896	90,049	283	103,322	236	86,101	54,258
7	0.583		86,523	50,486	1,333,538	65,295	38,099	725,733	65,295	38,099	0.68	74,182	43,284	1.37	149,325	87,130	299	109,047	249	90,872	53,023
8	0.540		86,523	46,746	1,405,395	71,857	38,822	797,590	71,857	38,822	0.68	78,267	42,285	1.37	157,213	84,937	315	115,122	263	95,935	51,831
9	0.500		86,523	43,283	1,484,553	79,158	39,599	876,748	79,158	39,599	0.69	84,068	42,055	1.37	167,008	83,545	333	121,571	277	101,309	50,680
10	0.463		86,523	40,077	1,571,838	87,285	40,430	964,033	87,285	40,430	0.72	92,144	42,680	1.40	179,272	83,037	352	128,416	293	107,013	49,568
11	0.429		86,523	37,108	1,668,178	96,340	41,318	1,060,373	96,340	41,318	0.76	103,193	44,258	1.44	194,712	83,509	371	135,683	310	113,069	48,494
12	0.397		86,523	34,360	1,774,613	106,435	42,267	1,166,808	106,435	42,267	0.82	118,097	46,898	1.49	214,215	85,068	393	143,400	327	119,500	47,455
13	0.368		86,523	31,814	1,892,312	117,699	43,278	1,284,506	117,699	43,278	0.91	137,952	50,725	1.58	238,884	87,837	415	151,596	346	126,330	46,451
14	0.340		86,523	29,458	2,022,586	130,274	44,353	1,414,781	130,274	44,353	1.02	164,129	55,879	1.68	270,091	91,956	439	160,300	366	133,584	45,480
15	0.315		86,523	27,276	2,166,910	144,324	45,497	1,559,105	144,324	45,497	1.17	198,326	62,521	1.83	309,542	97,581	464	169,547	387	141,289	44,540
16	0.292		86,523	25,255	2,326,942	160,032	46,712	1,719,137	160,032	46,712	1.35	242,649	70,827	2.00	359,344	104,889	491	179,371	409	149,475	43,630
17	0.270		86,523	23,385	2,504,546	177,604	48,001	1,896,741	177,604	48,001	1.58	299,702	81,000	2.22	422,103	114,081	520	189,808	433	158,174	42,749
18	0.250		86,523	21,652	2,701,820	197,273	49,367	2,094,014	197,273	49,367	1.86	372,695	93,267	2.49	501,029	125,382	550	200,900	458	167,417	41,896
19	0.232		86,523	20,049	2,921,124	219,304	50,815	2,313,319	219,304	50,815	2.19	465,584	107,882	2.82	600,075	139,045	582	212,688	485	177,240	41,069
20	0.215		86,523	18,563	3,165,117	243,994	52,348	2,557,312	243,994	52,348	2.59	583,231	125,131	3.22	724,099	155,354	617	225,217	514	187,680	40,267
Total			1,730,467	849,499			1,746,209			1,183,426			1,224,094			2,028,865					992,872

Average Incremental Cost (AIC) = Present Value of Costs / PV of Water Consumed

AIC (O & M)	**R 2,028,865 /**	**992,872 m3 =**		**R 2.04 /m3**
AIC (replacement)	**R 1,224,094 /**	**992,872 m3 =**	**R 1.23 /m3**	
AIC (O & M + replacement)				**R 3.28 /m3**
AIC (capital difference)	**R 1,183,426 /**	**992,872 m3 =**	**R 1.19 /m3**	
AIC (O & M + replace + capital difference)				**R 4.47 /m3**
AIC (capital cost of communal standpipe supply + interest)	**R 849,499 /**	**992,872 m3 =**	**R 0.86 /m3**	
AIC (O & M + replace + full capital redemption)		**m3 =**		**R 5.32 /m3**

1 Capital cost derived from best fit curve of capital cost vs consumption: Capital cost (R) =4.773(water produced(m3/d))^2 + 1,390.6*(production) + 492,932
Note: this capital investment is an averaged figure corresponding to the scale of infrastructure needed to meet the demand consumption,
in reality, this investment would be more 'lumpy' as various capital items needed upgrading

*2 Based on unit costs of replacement cost vs consumption:
Unit cost (R/m3) = .00002*(production(m3/d))^2 - 0.0123*(production) + 2.5698

*3 Unit costs derived from best fit curve of cost vs consumption data
O & M cost (R/m3) = 0.00002(production (m3/d))^2 - 0.0125(production) + 3.3486

*4 Repayment of principle loan + interest set on Capital Recovery Factor at 13% (consistent with PDG, 1996) over 20 years.

Appendix 5.9 Cash flows - option 1

Assumptions:

			Tariff
1	DWAF subsidises capital cost of RDP level of service (scenario 1) =	R607,805	(R 324 / capita)
2	Communal standpipe users pay flat rate based on O & M costs for RDP LOS		R 16 /house/month
3	Individual connections (yard & house) pay AIC based on O & M, depreciation + capital differenc		R 4.35 /m3
	+ connection costs (half up front + half over 5 yr.)		/m3
4	Institutions pay AIC based on O & M + deprec. + full capital cost		R 6.44 /m3

Cash Flow

Year	Revenue									Cost					Net revenue		Net Present Value		Internal Rate of Return	
	Standpipes			Individual connections			Institutional water		Total	Capital difference	O & M	Replacement	O & M + replace.	Total	(Revenue - cost)		DF	PV	7.6%	
	no.	R/mon	R/yr.	no.	m3/d	R/yr.	m3/d	R/yr.							Annual	Cumulative	8%			
1	250	4,032	48,387	62	35	54,993	11	25,430	128,811	70,650	82,580	56,100	138,680	209,330	- 80,520	- 80,520	0.926	- 74,555	0.930	- 74,860
2	253	4,092	49,101	67	37	58,622	11	26,432	134,155	9,238	84,583	57,090	141,673	150,911	- 16,756	- 97,275	0.857	- 14,365	0.864	- 14,483
3	257	4,150	49,800	71	39	62,492	12	27,482	139,774	9,849	86,609	58,056	144,664	154,513	- 14,739	- 112,014	0.794	- 11,700	0.804	- 11,844
4	260	4,207	50,481	76	42	66,616	12	28,585	145,682	10,509	88,654	58,991	147,646	158,155	- 12,473	- 124,487	0.735	- 9,168	0.747	- 9,319
5	264	4,262	51,143	81	45	71,013	13	29,742	151,898	11,224	90,718	59,892	150,609	161,834	- 9,936	- 134,423	0.681	- 6,762	0.695	- 6,902
6	267	4,315	51,781	86	48	75,699	13	30,958	158,438	11,999	92,796	60,752	153,547	165,546	- 7,108	- 141,531	0.630	- 4,479	0.646	- 4,590
7	270	4,366	52,393	92	51	80,696	14	32,235	165,323	12,839	94,886	61,566	156,452	169,291	- 3,967	- 145,499	0.583	- 2,315	0.600	- 2,382
8	273	4,415	52,975	98	54	86,022	14	33,578	172,574	13,751	96,986	62,329	159,314	173,065	- 491	- 145,990	0.540	- 265	0.558	- 274
9	276	4,460	53,523	104	58	91,699	15	34,989	180,211	14,741	99,093	63,035	162,128	176,869	3,342	- 142,648	0.500	1,672	0.519	1,734
10	279	4,503	54,034	111	62	97,751	16	36,473	188,259	15,817	101,207	63,679	164,886	180,704	7,555	- 135,093	0.463	3,499	0.482	3,645
11	281	4,542	54,503	118	66	104,203	16	38,035	196,741	16,989	103,326	64,258	167,584	184,573	12,168	- 122,925	0.429	5,219	0.449	5,458
12	283	4,577	54,926	126	70	111,080	17	39,679	205,685	18,265	105,452	64,768	170,220	188,485	17,200	- 105,725	0.397	6,830	0.417	7,173
13	285	4,608	55,298	134	75	118,411	18	41,409	215,118	19,656	107,586	65,208	172,794	192,449	22,669	- 83,056	0.368	8,335	0.388	8,789
14	287	4,634	55,612	143	79	126,226	18	43,232	225,070	21,174	109,733	65,578	175,310	196,484	28,586	- 54,470	0.340	9,732	0.360	10,304
15	288	4,655	55,864	153	85	134,557	19	45,152	235,573	22,831	111,900	65,881	177,782	200,613	34,960	- 19,510	0.315	11,021	0.335	11,716
16	289	4,671	56,047	163	90	143,438	20	47,175	246,660	24,643	114,100	66,125	180,226	204,869	41,792	22,282	0.292	12,199	0.312	13,021
17	290	4,680	56,155	174	96	152,905	21	49,308	258,368	26,625	116,349	66,322	182,671	209,297	49,071	71,353	0.270	13,262	0.290	14,215
18	290	4,682	56,179	185	103	162,997	22	51,557	270,733	28,796	118,669	66,490	185,160	213,956	56,777	128,130	0.250	14,208	0.269	15,291
19	289	4,676	56,114	197	109	173,755	23	53,930	283,798	31,176	121,093	66,656	187,749	218,925	64,874	193,004	0.232	15,032	0.250	16,243
20	289	4,662	55,950	210	117	185,222	24	56,433	297,605	33,786	123,661	66,856	190,517	224,303	73,302	266,306	0.215	15,727	0.233	17,064
										353,908		1,259,633						**- 6,873**		**- 0**

Typical tariff

	Consumption		Connection		Tariff		Total	Average
		m3/house	up front	/mon			R/house	actual
	l/c/d	/month			R/m3	R	/month	unit cost
Standpipe	25	4,566					**16**	(3.54)
Yard connection	80	14,610	471	12	4.35	64	**75**	(5.15)
House connection	130	23,741	621	15	4.35	103	**119**	(5.00)
Institutions					R 6.44			

Comments:

1 Institutions and individual connections subsidise communal standpipes and UFW

2 Communal standpipes don't pay actual cost of O & M - pay O & M cost for 'RDP level of service'

3 WSP needs incentives to reduce UFW

4 Main influences on net present value:

Annual increase in individual connections (this example is set at 4% per anum)

Cash flows - option 2

Assumptions:

		Tariff
1	DWAF subsidises capital cost of RDP level of service (scenario 1) = R607,805	(R 324 / capita)
2	Communal standpipe users pay flat rate based on O & M costs for RDP LOS	R 5 /house/month
3	Individual connections (yard & house) pay AIC based on O & M, depreciation + capital differenc	R 6.16 /m3
	+ connection costs (half up front + half over 5 yr.)	/m3
4	Institutions pay AIC based on O & M + deprec. + full capital cost	R 6.16 /m3

Cash Flow

	Revenue									Cost					Net revenue		Net Present		Internal Rate	
Year										Capital	O & M	Replace	O & M +	Total	(Revenue - cost)		Value		of Return	
	Standpipes			Individual connections			Institutional water		Total	difference		ment	replace.				DF	PV	8.0%	
	no.	R/mon	R/yr.	no.	m3/d	R/yr.	m3/d	R/yr.							Annual	Cumulative	8%			
1	250	1,248	14,976	62	35	77,965	11	24,338	117,279	70,650	82,580	56,100	138,680	209,330	- 92,052	- 92,052	0.926	- 85,233	0.926	- 85,233
2	253	1,266	15,197	67	37	83,111	11	25,296	123,604	9,238	84,583	57,090	141,673	150,911	- 27,307	- 119,359	0.857	- 23,412	0.857	- 23,412
3	257	1,284	15,413	71	39	88,596	12	26,301	130,311	9,849	86,609	58,056	144,664	154,513	- 24,202	- 143,561	0.794	- 19,213	0.794	- 19,213
4	260	1,302	15,624	76	42	94,443	12	27,357	137,424	10,509	88,654	58,991	147,646	158,155	- 20,731	- 164,292	0.735	- 15,238	0.735	- 15,238
5	264	1,319	15,829	81	45	100,677	13	28,464	144,970	11,224	90,718	59,892	150,609	161,834	- 16,864	- 181,156	0.681	- 11,477	0.681	- 11,477
6	267	1,336	16,026	86	48	107,321	13	29,628	152,975	11,999	92,796	60,752	153,547	165,546	- 12,571	- 193,728	0.630	- 7,922	0.630	- 7,922
7	270	1,351	16,216	92	51	114,404	14	30,850	161,470	12,839	94,886	61,566	156,452	169,291	- 7,821	- 201,548	0.583	- 4,563	0.583	- 4,563
8	273	1,366	16,396	98	54	121,955	14	32,135	170,486	13,751	96,986	62,329	159,314	173,065	- 2,579	- 204,127	0.540	- 1,393	0.540	- 1,393
9	276	1,380	16,566	104	58	130,004	15	33,485	180,055	14,741	99,093	63,035	162,128	176,869	3,186	- 200,941	0.500	1,594	0.500	1,594
10	279	1,394	16,724	111	62	138,584	16	34,906	190,214	15,817	101,207	63,679	164,886	180,704	9,511	- 191,430	0.463	4,405	0.463	4,405
11	281	1,406	16,869	118	66	147,731	16	36,401	201,001	16,989	103,326	64,258	167,584	184,573	16,427	- 175,003	0.429	7,045	0.429	7,045
12	283	1,417	17,000	126	70	157,481	17	37,974	212,455	18,265	105,452	64,768	170,220	188,485	23,970	- 151,033	0.397	9,519	0.397	9,519
13	285	1,426	17,115	134	75	167,875	18	39,630	224,620	19,656	107,586	65,208	172,794	192,449	32,170	- 118,862	0.368	11,829	0.368	11,829
14	287	1,434	17,212	143	79	178,955	18	41,374	237,541	21,174	109,733	65,578	175,310	196,484	41,057	- 77,806	0.340	13,978	0.340	13,978
15	288	1,441	17,290	153	85	190,766	19	43,211	251,267	22,831	111,900	65,881	177,782	200,613	50,655	- 27,151	0.315	15,968	0.315	15,968
16	289	1,446	17,347	163	90	203,356	20	45,148	265,851	24,643	114,100	66,125	180,226	204,869	60,982	33,831	0.292	17,800	0.292	17,800
17	290	1,448	17,380	174	96	216,778	21	47,189	281,347	26,625	116,349	66,322	182,671	209,297	72,050	105,882	0.270	19,473	0.270	19,473
18	290	1,449	17,388	185	103	231,085	22	49,342	297,815	28,796	118,669	66,490	185,160	213,956	83,859	189,740	0.250	20,986	0.250	20,986
19	289	1,447	17,367	197	109	246,337	23	51,612	315,317	31,176	121,093	66,656	187,749	218,925	96,392	286,133	0.232	22,335	0.232	22,335
20	289	1,443	17,317	210	117	262,595	24	54,008	333,920	33,786	123,661	66,856	190,517	224,303	109,617	395,749	0.215	23,518	0.215	23,518
										353,908		1,259,633						**- 0**		**0**

Typical tariff

	Consumption		Connection		Tariff		Total	Average
		m3/house	up front	/mon			R/house	actual
	l/c/d	/month			R/m3	R	/month	unit cost
Standpipe	25	4,566					**5**	(1.10)
Yard connection	80	14,610	471	12	6.16	90	**102**	(6.96)
House connection	130	23,741	621	15	6.16	146	**162**	(6.81)
Institutions					R 6.16			

Comments:

1. Institutions and individual connections subsidise communal standpipes and UFW
2. Communal standpipes don't pay actual cost of O & M - pay O & M cost for 'RDP level of service'
3. WSP needs incentives to reduce UFW
4. Main influences on net present value:
   Annual increase in individual connections (this example is set at 4% per anum)

Cash flows - option 3

Assumptions:

			Tariff
1	DWAF subsidises capital cost of RDP level of service (scenario 1) =	R607,805	(R 324 / capita)
2	Communal standpipe users pay flat rate based on O & M costs for RDP LOS		R 0 /house/month
3	Individual connections (yard & house) pay AIC based on O & M, depreciation + capital differenc		R 5.63 /m3
	+ connection costs (half up front + half over 5 yr.)		/m3
4	Institutions pay AIC based on O & M + deprec. + full capital cost		R 11.26 /m3

Cash Flow

Year	Revenue									Cost					Net revenue		Net Present Value		Internal Rate of Return	
	Standpipes			Individual connections			Institutional water		Total	Capital difference	O & M	Replacement	O & M + replace.	Total	(Revenue - cost)		DF	PV	8.0%	
	no.	R/mon	R/yr.	no.	m3/d	R/yr.	m3/d	R/yr.							Annual	Cumulative	8%			
1	250	-	-	62	35	71,223	11	44,466	115,689	70,650	82,580	56,100	138,680	209,330	- 93,641	- 93,641	0.926	- 86,705	0.926	- 86,705
2	253	-	-	67	37	75,924	11	46,217	122,141	9,238	84,583	57,090	141,673	150,911	- 28,770	- 122,412	0.857	- 24,666	0.857	- 24,666
3	257	-	-	71	39	80,935	12	48,054	128,989	9,849	86,609	58,056	144,664	154,513	- 25,524	- 147,936	0.794	- 20,262	0.794	- 20,262
4	260	-	-	76	42	86,276	12	49,982	136,258	10,509	88,654	58,991	147,646	158,155	- 21,897	- 169,833	0.735	- 16,095	0.735	- 16,095
5	264	-	-	81	45	91,971	13	52,006	143,976	11,224	90,718	59,892	150,609	161,834	- 17,857	- 187,690	0.681	- 12,154	0.681	- 12,154
6	267	-	-	86	48	98,041	13	54,131	152,172	11,999	92,796	60,752	153,547	165,546	- 13,375	- 201,065	0.630	- 8,428	0.630	- 8,428
7	270	-	-	92	51	104,511	14	56,365	160,876	12,839	94,886	61,566	156,452	169,291	- 8,415	- 209,480	0.583	- 4,910	0.583	- 4,910
8	273	-	-	98	54	111,409	14	58,712	170,121	13,751	96,986	62,329	159,314	173,065	- 2,944	- 212,424	0.540	- 1,591	0.540	- 1,591
9	276	-	-	104	58	118,762	15	61,180	179,942	14,741	99,093	63,035	162,128	176,869	3,073	- 209,351	0.500	1,537	0.500	1,537
10	279	-	-	111	62	126,600	16	63,775	190,375	15,817	101,207	63,679	164,886	180,704	9,672	- 199,679	0.463	4,480	0.463	4,480
11	281	-	-	118	66	134,956	16	66,506	201,462	16,989	103,326	64,258	167,584	184,573	16,888	- 182,791	0.429	7,243	0.429	7,243
12	283	-	-	126	70	143,863	17	69,380	213,243	18,265	105,452	64,768	170,220	188,485	24,758	- 158,033	0.397	9,832	0.397	9,832
13	285	-	-	134	75	153,358	18	72,405	225,763	19,656	107,586	65,208	172,794	192,449	33,314	- 124,719	0.368	12,250	0.368	12,250
14	287	-	-	143	79	163,480	18	75,592	239,072	21,174	109,733	65,578	175,310	196,484	42,588	- 82,131	0.340	14,499	0.340	14,499
15	288	-	-	153	85	174,269	19	78,949	253,218	22,831	111,900	65,881	177,782	200,613	52,606	- 29,525	0.315	16,584	0.315	16,584
16	289	-	-	163	90	185,771	20	82,487	268,258	24,643	114,100	66,125	180,226	204,869	63,390	33,864	0.292	18,503	0.292	18,503
17	290	-	-	174	96	198,032	21	86,217	284,249	26,625	116,349	66,322	182,671	209,297	74,952	108,816	0.270	20,257	0.270	20,257
18	290	-	-	185	103	211,102	22	90,150	301,252	28,796	118,669	66,490	185,160	213,956	87,296	196,112	0.250	21,846	0.250	21,846
19	289	-	-	197	109	225,035	23	94,298	319,333	31,176	121,093	66,656	187,749	218,925	100,408	296,520	0.232	23,266	0.232	23,266
20	289	-	-	210	117	239,887	24	98,675	338,562	33,786	123,661	66,856	190,517	224,303	114,259	410,780	0.215	24,514	0.215	24,514
										353,908		1,259,633						**0**		**0**

Typical tariff

	Consumption		Connection		Tariff		Total	Average
	l/c/d	m3/house /month	up front	/mon	R/m3	R	R/house /month	actual unit cost
Standpipe	25	4,566					**0**	(0.00)
Yard connection	80	14,610	471	12	5.63	82	**94**	(6.43)
House connection	130	23,741	621	15	5.63	134	**149**	(6.28)
Institutions					R 11.26			

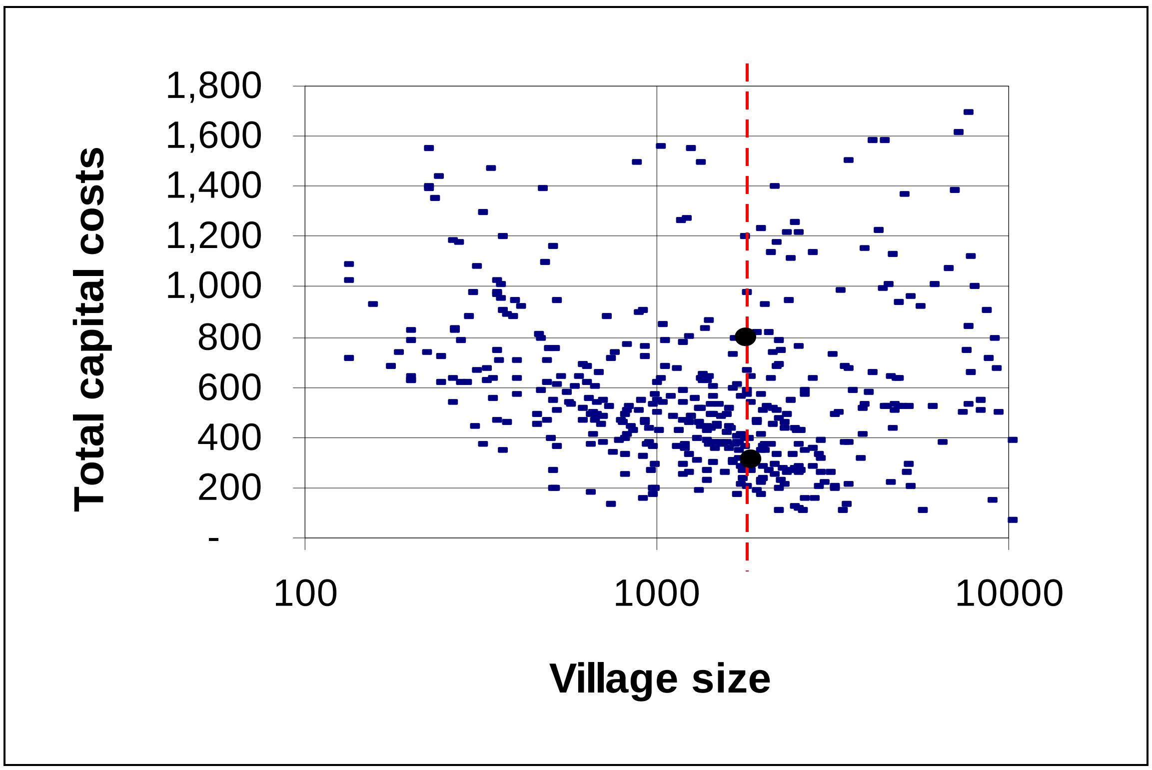
Comments:

1. Institutions and individual connections subsidise communal standpipes and UFW
2. Communal standpipes don't pay actual cost of O & M - pay O & M cost for 'RDP level of service'
3. WSP needs incentives to reduce UFW
4. Main influences on net present value:
   Annual increase in individual connections (this example is set at 4% per anum)

Appendix 5.10

Distribution of capital costs for RWS in SA (1995)

Comparison between this study and financial modelling exercise synthesised by Palmer Development Group (1996). PDG study calculated the capital cost of 'scenario 2' (closest equivalent scenario to this study) for 467 villages in 5 regional studies. Per capita capital costs ranged from R200 - R4,000. Graph shows 95% of villages < R1,800 / capita in 1995 SA Rands.



Seokodibeng (1,874)

Costs of six scenarios in Seokodibeng case study (between R324 and R802 per capita)

65.0	150.00000	19.72
80.0	150.00000	28.64
100.0	150.00000	41.95
110.0	150.00000	55.32
125.0	150.00000	68.89
150.0	150.00000	86.22
175.0	150.00000	132.06
300.0	150.00000	200.00
400.0	150.00000	300.00
500.0	150.00000	400.00
600.0	150.00000	500.00
700.0	150.00000	600.00

80.0	2541.00	72.77	140.08
100.0	210.00	8.81	148.89

Pipe Details

Pipe; No.	From; Node	To; Node	Peak Flow; (lps)	Diam; (mm)	Hazen's; Const	HL; (m)	HL/1000; (m)	Length (m)
1	1	2	6.280	100.0	150.00000	1.32	6.29	210.00
2	4	3	0.170	50.0	150.00000	0.03	0.20	150.00
3	5	4	0.340	50.0	150.00000	0.12	0.80	150.00
4	6	5	0.510	50.0	150.00000	0.05	1.67	30.00
5	6	7	0.170	50.0	150.00000	0.01	0.20	50.00
6	8	6	0.680	50.0	150.00000	0.30	3.00	100.00
7	9	8	0.850	50.0	150.00000	0.57	4.56	125.00
8	2	9	1.020	50.0	150.00000	0.76	6.33	120.00
45	2	10	5.260	80.0	150.00000	0.80	13.33	60.00
9	10	11	5.090	80.0	150.00000	1.26	12.60	100.00
10	11	12	0.170	50.0	150.00000	0.02	0.20	100.00
11	11	13	4.920	80.0	150.00000	1.18	11.80	100.00
12	13	14	4.750	80.0	150.00000	2.11	11.11	190.00
13	14	15	4.580	80.0	150.00000	1.97	10.37	190.00
14	15	16	4.410	80.0	150.00000	1.84	9.68	190.00
15	16	17	4.240	80.0	150.00000	1.71	9.00	190.00
16	17	18	4.070	80.0	150.00000	1.58	8.32	190.00
17	18	19	3.900	80.0	150.00000	1.46	7.68	190.00
18	19	20	3.730	80.0	150.00000	1.35	7.11	190.00
19	20	21	3.560	80.0	150.00000	1.24	6.53	190.00
20	21	22	3.390	80.0	150.00000	1.13	5.95	190.00
21	22	23	3.220	80.0	150.00000	1.14	5.43	210.00
22	23	24	0.170	50.0	150.00000	0.01	0.17	60.00
23	23	25	3.050	80.0	150.00000	0.88	4.89	180.00
24	25	26	2.880	80.0	150.00000	0.80	4.42	181.00
25	26	27	0.170	50.0	150.00000	0.02	0.20	100.00
26	26	28	2.710	65.0	150.00000	2.16	10.80	200.00
27	28	29	2.540	65.0	150.00000	0.05	10.00	5.00
28	29	30	0.170	50.0	150.00000	0.03	0.20	150.00
29	29	31	2.370	65.0	150.00000	1.31	8.45	155.00
30	31	32	2.370	65.0	150.00000	1.85	8.41	220.00
31	32	33	2.200	65.0	150.00000	1.84	7.36	250.00
32	33	34	2.030	65.0	150.00000	0.55	6.32	87.00
33	34	35	0.170	50.0	150.00000	0.12	0.24	500.00
34	34	36	1.860	65.0	150.00000	0.81	5.40	150.00
35	36	37	1.690	65.0	150.00000	0.23	4.60	50.00
36	37	38	1.190	65.0	150.00000	0.35	2.33	150.00
37	38	39	1.020	50.0	150.00000	0.87	6.39	136.23
				65.0	150.00000	0.02	1.45	13.77
38	39	40	0.510	50.0	150.00000	0.39	1.77	220.00
39	40	41	0.340	50.0	150.00000	0.18	0.82	220.00
40	41	42	0.170	50.0	150.00000	0.05	0.23	220.00
41	39	43	0.510	50.0	150.00000	0.05	1.67	30.00
42	43	44	0.340	50.0	150.00000	0.14	0.82	170.00
43	44	45	0.170	50.0	150.00000	0.01	0.33	30.00
44	44	46	0.170	50.0	150.00000	0.07	0.23	300.00

Node Details

Node; No.	Peak Flow; (lps)	Elevation; (m)	H G L; (m)	Cal Pres; (m)	Spc Pres (m) Pres. (Y)
1 S	6.280	100.00	100.00	0.00	10.00
2	0.000	67.00	98.68	31.68	10.00
3 T	-0.170	82.00	96.84	14.84	10.00
4	-0.170	79.00	96.87	17.87	10.00
5	-0.170	77.00	97.00	20.00	10.00
6	0.000	76.00	97.05	21.05	10.00
7 T	-0.170	73.00	97.04	24.04	10.00
8	-0.170	70.00	97.35	27.35	10.00
9	-0.170	69.00	97.92	28.92	10.00
10	-0.170	68.00	97.88	29.88	10.00
11	0.000	66.00	96.62	30.62	10.00
12 T	-0.170	63.00	96.59	33.59	10.00
13	-0.170	61.00	95.43	34.43	10.00
14	-0.170	59.00	93.32	34.32	10.00
15	-0.170	57.00	91.35	34.35	10.00
16	-0.170	55.00	89.52	34.52	10.00
17	-0.170	43.00	87.81	44.81	10.00
18	-0.170	52.00	86.22	34.22	10.00
19	-0.170	50.00	84.76	34.76	10.00
20	-0.170	49.00	83.41	34.41	10.00
21	-0.170	47.00	82.17	35.17	10.00
22	-0.170	42.00	81.04	39.04	10.00
23	0.000	41.00	79.91	38.91	10.00
24 T	-0.170	36.00	79.90	43.90	10.00
25	-0.170	39.00	79.03	40.03	10.00
26	0.000	42.00	78.23	36.23	10.00
27 T	-0.170	35.00	78.21	43.21	10.00
28	-0.170	50.00	76.07	26.07	10.00
29	0.000	52.00	76.03	24.03	10.00
30 T	-0.170	43.00	75.99	32.99	10.00
31	0.000	53.00	74.72	21.72	10.00
32	-0.170	50.00	72.86	22.86	10.00
33	-0.170	43.00	71.03	28.03	10.00
34	0.000	40.00	70.48	30.48	10.00
35 T	-0.170	55.00	70.36	15.36	10.00
36	-0.170	42.00	69.67	27.67	10.00
37	-0.500	44.00	69.45	25.45	10.00
38	-0.170	46.00	69.09	23.09	10.00
39	0.000	47.00	68.20	21.20	10.00
40	-0.170	50.00	67.81	17.81	10.00
41	-0.170	53.00	67.63	14.63	10.00
42 T	-0.170	57.00	67.58	10.58	10.00
43	-0.170	50.00	68.15	18.15	10.00
44	0.000	55.00	68.01	13.01	10.00
45 T	-0.170	58.00	68.00	10.00	10.00
46 T	-0.170	41.00	67.94	26.94	10.00