(3) Human resources are not optimally deployed among water sector organisations, partly as a result of limited interactive resource planning. Due to shifting roles and new administrative circumstances, some organisations are overstaffed while others have minimal human resource capacity.

(4) Many Third Tier organisations are not sure of their roles in local and regional development planning, and in planning around the integrated provision of services. Programmes to support local planning have been initiated by DWAF (eg Area Planning Forums) and District Councils (eg Zonal Planning as initiated by Rustenburg DC). The DWAF network of Area Planning Forums remains to be fully deployed, whilst the planning zones are only in the area of jurisdiction of the Rustenburg DC.

(5) Local government has to manage a range of services. In many cases there is a lack of integrated service planning and delivery. In some cases, water sector institutions have promoted a narrow water-oriented perspective in dealings with the Third Tier.

(6) Community involvement is widely promoted and encouraged, but its practice is variable and outcomes are of differing value to the communities concerned.

3.4 Policy and Strategy Recommendations

3.4.1 General Description and Context

A key component of Phase 1 is policy formulation and strategy definition. Policy is understood to include the broad public policy that underpins the service delivery in the water sector, and policies that might be adopted by organisations in the water sector with respect to their own operations (for example policy regarding community participation and involvement). Strategy is understood imply a programme of purposeful action leading to a desired outcome.

The policy and strategy recommendations from this study support the following processes:

(1) Reform and revision of enabling public policy.

(2) Formulation of policy specific to Magalies Water and partner organisations in the water and local government sectors.

(3) Formulation of strategies by MW, DWAF and other relevant organisations which will lead to the successful extension of the supply capability of MW, and the provision of effective and sustainable support to water supply and management capacity in the Third Tier.

3.4.2 Link to Gap Analysis

The gap analysis described in Supporting Report C is the foundation of the policy and strategy recommendations. The following key features of the linked Gap Analysis and Policy and Strategy processes should be noted:

(1) The policy and strategy recommendations are based on an inclusive and relatively objective understanding of the gaps between development targets laid out in policy and the present situation as revealed in the situational analysis.

(2) The process combined participatory vehicles (in the form of workshops and expert/stakeholder task teams) with the progressive refinement of gaps and policy and strategy responses.

(3) The approach sought to generate an inclusive menu of policy and strategy options, which were then elaborated, combined or removed as a more complete understanding of priorities, capacity and relevance was developed.

3.4.3 Objectives of the Policy and Strategy Task

The broad objectives of the policy and strategy task are the following:

(1) To facilitate and guide the expansion of Magalies Water and associated institutions through practical recommendations regarding policy and strategy.

(2) To identify areas of national policy that support/hinder the expansion of MW, and to propose actions to be taken.

(3) To identify areas of policy in specific water sector and related institutions that require attention, and to propose appropriate actions.

(4) To propose strategies to deal with institutional and technical gaps that are likely to hinder the expansion of MW, together with strategies that will facilitate the expansion process.

Due to the interdependent nature of the water sector, these objectives do not imply that MW is the sole actor. The recommendations consider the roles and contributions of various levels of government, together with non-government organisations.

3.4.4 The Planning Context

Policy and strategy formulation has had to recognise aspects of the South African policy and planning context, and of the policy and planning environment of the water sector. Development constraints were outlined in Section 3.3 above. Other key issues are the following:

(1) The transition challenge. The MW study is one component of a national and multi-sectoral initiative to ensure that the public sector reflects the ideals and objectives of the new democratic constitution and government. The implications of this wide-ranging transformation for the MW Study are the following.

(a) Policies, institutional arrangements and the deployment of resources are in a state of flux. Whilst MW is seeking to respond to new policy-based challenges, associated organisations are engaged in the same process. It is thus important to be informed about initiatives elsewhere, and to link complimentary activities if possible. The interactive approach adopted for the policy and strategy process has sought to retain the necessary communication with key water sector actors.

(b) Whilst the White Paper on Water Supply and Sanitation presents a vision of interlocking institutions in the water sector, there are substantial gaps, particularly at Third Tier level (see 3.3.4 above). This means that policy and strategy options must address *interim* solutions, as well as those that will emerge when all resources are engaged as envisaged in policy.

(c) Lack of Third Tear capacity is described above (Section 3.3.4). An implication for the MW study is that it has been necessary to carry stakeholders along as the policy and strategy process has unfolded. However, in many situations the stakeholders are difficult to engage. This is particularly the case at local government level, where some authorities are newly elected, and where some areas have not formulated agreed local government structures.

(d) Roles and responsibilities are broadly defined in policy (see Section 2.4), but in many cases these remain unclear. Whilst it is necessary to clarify roles, it is also important to allow room for organisations in the water sector to adopt unusual roles during the transitionary period. Partnership and networking require special attention, as reflected in the policy and strategy recommendations.

(2) Retaining a long term perspective. The demands of transition are so complex that it is easy to lose sight of objectives beyond the transitionary period. In the MW case, it is necessary to see the organisation and its role in two time frames; short to medium term and long term. A concern is not to fix transitionary structures and procedures so that they become an impediment to post-transition operations. Present civil service restructuring illustrates the difficulty of changing entrenched institutions.

3.4.5 Overview of Steps in the Policy and Strategy Process

The flow of activities from Gap Analysis to Policy and Strategy Recommendations is illustrated in Figure 3.1. The shaded portion is the component of the process in which the identification, elaboration and testing of possible policy and strategy responses was the primary objective. The key steps are summarised in Supporting Report C and are not repeated here.

3.4.6 Evaluation of the Process

In evaluating the policy and strategy process outlined above, four themes are addressed: participation; defining the field; consolidation and contextualisation.

(1) Participation. The policy and strategy processes was designed specifically to invite and encourage stakeholder participation. An indication of the success of the participatory approach is the quality of the material generated. Another is the willingness of stakeholders to attend workshops and meetings. Details of participation are given in Chapter 2 of the Supporting Report C.

(2) Defining the Field. In an environment of change, it is common for policies and strategies to be built around the agendas of sectoral interests. The policy and strategy process has sought to address this by basing proposals on a carefully researched situational analysis, and on an understanding of the development targets set by policy and by key practitioners in the water sector. A measure of the effectiveness of this methodology is level of consensus achieved around the definition of core gaps/problems. As a result planning has the assurance that no major issue or sectoral perspective has been neglected.

(3) Consolidation of Findings. The process followed allowed for the progressive consolidation of findings and recommendations. This approach sought to build confidence and to permit stakeholders to take ownership of the policy and strategy recommendations that emerged. The true test of the effectiveness of the process will be when MW and others seek to implement the recommendations. However, it is possible to make recommendations in the belief that they will be positively received by most stakeholders.

(4) Contextualisation. Exposing the policy and strategy formulation process to wider participation has helped to ensure that the recommendations are not out of context, or out of step with developments in the broader water sector. A test of the relevance of the policy and strategy recommendations is the endorsement of many of these by DWAF, MW and representatives of the Third Tier. An indication that they are in step with emerging policy and practice is the fact that many of the recommendations are matched by complimentary actions in DWAF, MW, and in some of the District Councils.

3.4.7 Background to Policy and Strategy Recommendations

In developing a plan for the extension of MW, the JICA study has had to address the difficult task of planning in a sector characterised by highly uneven development, change and uncertainty. In this context, the recommendations recognise both short and long term roles for Water Boards; and they take the form of policy and strategy options.

(1) Short and Long Term Roles for Water Boards

The policy and strategy recommendations have to be placed in the framework of the short and long term roles of Water Boards (discussed in detail in Chapter 6). National policy requires water boards to extend their activities whilst sustaining their core role of wholesaling bulk water. In the short to medium term, the boards are expected to extend supply areas, and to provide various support functions to the Third Tier. These support functions are not clearly defined in policy. In the long term, it is envisaged that the boards will return to the bulk supply role of the past, but with additional bulk customers.

The implementation of this policy has major implications for MW and other boards:

(a) The extension of areas of supply, and the provision of bulk services to a wider spectrum of customers.

(b) The provision of various forms of Third Tier support. For planning purposes there are different of types of support, for example:

1) Interim project implementation where Third Tier capacity is not present, or where the Third Tier is not ready to implement projects.

2) Technical and capacity building support to the Third Tier.

3) Development of new bulk markets. The above forms of Third Tier support are of short to medium term relevance. A longer term Third Tier support issue is the development of new bulk business and reliable bulk customers.

(2) Policy and Strategy Options

Because the implementation of the new water supply and sanitation policy requires cooperation and partnership among actors directly and indirectly involved in water, it is inappropriate to propose policy and strategy initiatives unilaterally, or purely from the perspective of MW. Hence recommendations are framed as *options*, which must be considered by the Board of MW, by DWAF and by other actors such as the District Councils and Local Authorities. A process to take discussion around these options further is discussed in later in this Chapter, and in Chapters 6 and 7.

3.4.8 "Symptomatic" Policy and Strategy Recommendations

The policy and strategy recommendations outlined below fall into two categories:

(1) Symptomatic recommendations. These are suggested actions which respond directly to identified gaps/problems. They address the evident symptoms, but do not consider the broader or collective implications of individual actions. In situations of transition and crisis management, symptomatic solutions often prevail.

(2) Systematic recommendations. These are proposed actions which consider the complex and interlinked nature of the water sector, and the interdependence of initiatives leading to the water supply vision of the White Paper. By taking a systems view of policy and strategy it is recognised that the way to tackle a problem or obstacle is not necessarily the most obvious or direct.

The symptomatic recommendations generated through the gap analysis process can be placed in the context of the challenges that face Magalies Water: extension of supply and support to the Third Tier. Details of the links between gaps and solutions are contained in Chapter 3 of Supporting Report D. Table 3-1 illustrates which of the recommended actions might be incorporated in strategies to extend supply, and which might be mobilised as Third Tier support strategies. Consideration is also given to initiatives that might support a strategy to develop new bulk markets. The table lists the options without specific reference to programming and responsibilities. The options might be regarded as tools to be used in the context of the systematic recommendations outlined in Section 3.4.10.

3.4.9 Background to Systematic Policy and Strategy Options

The recommendations tabulated above represent a set of problem-solution statements. The table does not identify catalytic actions which will clear obstacles impeding progress across a number of gaps/problems, nor does it assign any priority to the implementation of solutions. These matters are addressed in the integrated policy and strategy recommendations presented below.

A preliminary analysis of the linkages between the gaps/problems (Figure 3-2) shows how actions to address some gaps are likely to assist in other contexts. For example:

(1) Cost recovery and integrated service provision are made possible by activities such as planning, capacity building and the active assumption of roles and responsibilities, and

(2) These process activities in turn sit in an enabling/constraining environment which includes policy, expectations, resources and public involvement.

3.4.10 Integrated Policy and Strategy Recommendations and Action Plan.

The following section summarises the eleven key action areas recommended by the JICA Magalies Study. These recommendations emerge from an effort to:

(1) Identify critical initiatives with significant and cumulative impact.

(2) Cover the revealed priorities of the stakeholders.

(3) Define a manageable and implementable programme of action.

The first two recommendations have to do with the reform and clarification of enabling public policy, whilst the remaining nine refer to initiatives that might be taken by MW and partners in the water sector to ensure the implementation of the water supply vision of the White Paper on Water Supply and Sanitation.

3.4.11 Prerequisites for Action

It is often the case that insufficient attention is given to creating a platform for the implementation of solutions. This problem is particularly evident in the social, managerial and institutional fields. Figure 3-3 illustrates the elements of an effective implementation framework.

The key components of the framework are:

(1) Understanding by key players of issues, critical success factors, solutions and the implications of these solutions. Communication is central to understanding.

(2) Acceptance of the proposed solutions. Understanding does not imply acceptance, but it is an essential precondition. Acceptance requires a decision by stakeholders.

(3) Sponsorship of solutions. Implementation is often challenging, and might fail if

initiatives are not championed by an individual or an organisation.

(4) Allocating roles and responsibilities. This clarifies steps and accountability.

(5) Assessing and addressing capacity requirements. Common errors in solution implementation are to assume capacity, or to consider only some aspects of capacity. Figure 3-4 illustrates typical capacity requirements.

3.4.12 Dynamics of Change in the Study Area

Implementation issues that appear to require particular attention in the Study Area are:

(1) A potential lack of sponsorship due to the presence of multiple actors and evolving roles. To address this we recommend that a forum is created to provide leadership and support for the process of implementation. This recommendation is elaborated in Section 3.4.14.

(2) In the context of the above, clear allocation of roles and responsibilities is particularly important. Those allocated roles will have to differentiate clearly between acting as representatives of parent organisations and being part of a broader initiative in the Study Area. This is also discussed in Section 3.4.14.

(3) Limited capacity is a recognised problem, especially in the Third Tier. Hence it is likely that implementation of policy and strategy options will have to be prioritised and phased appropriately.

3.4.13 Implementation Strategy and Structure

Two principal recommendations form the basis of the implementation strategy.

(1) Coordinating forum

DWAF, MW and the District Councils in the extended supply area should create a coordinating forum to take the work of the study further. The term forum is chosen to indicate that this vehicle can accommodate broader consultation as necessary.

(a) Purpose. To enable key actors to engage interactively the policy and strategy options, technical solutions and implementation strategies. Also to gain commitment, to agree roles and responsibilities and to design action plans.

(b) Objective. To achieve meaningful and measurable progress toward implementation of the policy and strategy options, technical solutions and pilot projects.

(c) Leadership. MW should lead in the facilitation of the work of the forum.

(d) Participation. Key stakeholders in the area, and at least DWAF, MW, Rand Water, Rustenburg District Council, Eastern District Council, Highveld District Council.

(e) Duration. Determined by the parties. Given the nature of the challenge, the forum is likely to have a life of at least two years.

(f) Frequency of meeting. Agreed by the parties, but probably at least twice per year.

(g) Outputs. A number of outputs could be expected from the forum, including: action plans; role/responsibility allocations; agreements for sharing resources; joint submissions on policy; coordinated bi-lateral activity.

(2) Consensus critical path

It is strongly recommended that a formal plan be developed by the members of the forum. The plan would be the first task of the forum and should address the order and timing of key activities in critical path format.

(a) Purpose. To analyse issues, challenges, solutions and recommendations in order to plan the actions to be taken in a logical and sustainable manner.

(b) Objective. To create a realistic and accepted critical path for changes in the Study Area, together with the necessary detailed plans.

(c) Leadership. MW should lead the development of the plan.

(d) Participation. This would be an output of discussions with the forum.

(e) Timing. To address a rapidly changing environment, the plan should be in place by early 1997.

(f) Output/result. A formally documented plan with activities, allocated responsibilities, timing and critical path.

Table 3-1 : Symptomatic Recommendations by Extension Challenge

	Strategies to Extend Supply	Strategies to Develop New Bulk Markets	Strategies to Provide Third Tier Support
Resource and Infrastructure Development	Water balance investigation • Technical solutions study • Capital investment plan	Develop a classification of emerging bulk customers and prioritise assistance	
Policy: Change and Review	Shift in emphasis to guidelines, incentives, processes that will promote service delivery • Review RDP goals • Clarify implications of DFA. plan extension with this framework in mind	Explore DFA as a framework for local development planning • Use JICA study to understand local diversity	Provincial and area forums to discuss roles and responsibilities • Clarify RDP policy and response to service standard debate • Clarify policy positions on cost recovery, unauthorised connections and subsidies. and link these
Human Resource Development	Additional staff for new roles • Team and management development • Training/skills audit • Coordinated skills and training programmes • Plan appropriate deployment of sector human resources	Take strategic view on HR requirements of future bulk customers	Management capacity building • Training and skills audits on a regional/area basis • Coordinated skills and training programmes • Government allocations for Third Tier training • Clarify support roles of LWCs and train accordingly
Managerial and Organisational Change	Explore service cooperatives. led by D Councils • DWAF and W Boards engage more bilaterally • Emphasis on consultative and human relations oriented management and guidelines	Explore long term potential of service cooperatives • Third Tier support with characteristics of sustainable bulk customers in mind • Clarify and entrench local planning roles and responsibilities • Formulate clear handover strategy and responsibilities	Explore service cooperatives. led by D Councils. Deploy service cooperatives and support networks • Institute managerial and organisational conditions so that local authorities can borrow on their own account • Service and collection responsibilities clearly assigned and accepted • WB support in areas of strength (eg financial mgmt) • Pursue support roles of CBOs and LWCs (without undermining elected officials) • Build/support structures for integrated service delivery

	Strategies to Extend Supply	Strategies to Develop New Bulk Markets	Strategies to Provide Third Tier Support
Financial Management and Cost Recovery	Deploy and resource cost recovery managers and processes for new customers • Clarify instruments and preferred practices (balance incentives with pressure to pay) • Refine/modify financial planning and management procedures according to new roles and scenarios	Prepare a cost recovery plan with forecasts and targets	Discuss ways of linking payment to development, also preferred instruments and practices • Explore and test innovative "best practice" regarding recovery, incentives, and payment systems • Explore and discuss financing options for higher levels of service (also ways to deal with risk)
Business Unit Strategy	Explore short and long term pros and cons of business unit options	Devolve responsibility for market development to business units/ regions	Devolve Third Tier development tasks to business units/ regions
Supply Area Definition and Consolidation	Programme to deal with remaining boundary issues		
Third Tier Support	Clarify Third Tier support roles: eg interim emergency assistance at Third Tier level; development of future market	Strategy of Third Tier support which will develop new bulk market	Capacity building in all aspects of management • Discussions of roles and responsibilities, based on capability • Explore private sector roles and deploy • Service coops and support networks as capacity building and empowerment mechanisms • Govt seed capital for local institutions • Institute a revolving pool fund • Planning framework and guidelines relevant to Third Tier • Assist Third Tier to link water supply to local economic development

	Strategies to Extend Supply	Strategies to Develop New Bulk Markets	Strategies to Provide Third Tier Support
Communication and Representation	Build strong capacity to interact with communities • Mechanisms to exchange information on regional/area economic development planning • Board representative of emerging market • Devolution of community interaction functions • Design and implement clear communication strategy	Build strong capacity to interact with communities • Board representative of emerging market	Discussions of "best practice" at provincial and area forum (eg cost recovery success stories) • Area forums to monitor enabling environment for community involvement • Discussion of service integration and local best practice • Guidelines for local authorities seeking finance, including criteria applied by lenders • Marketing campaign linking the value of safe and reliable water supply to billing • Discussion of service standards policy, and financing options for higher levels of service

Table 3-2 : Policy and Strategy Recommendations

Proposal 1:	**Overall Policy Review**
Strategy Proposal	It is clear that many laws and regulations inherited from the previous system of government and service provision are not supportive of new water supply policy. It is recommended that the JICA Study and Magalies make inputs to relevant policy review processes. An example of an area where policy review seems necessary is rural water supply. Current policy makes no clear distinction between rural and other forms of water supply. Many stakeholders believe that review is necessary. Issues are: - Almost complete lack of resources in some cases. Paying for water may be impossible for some. - The isolated nature of schemes (many of which are stand-alone facilities). - Dispersed communities with little or no organisation. - Limited potential for development of supply schemes beyond basic arrangements.
Current Status	A water law review process is currently in progress.
Lead Actors	DWAF is leading the process. MW and JICA to present relevant material.
Policy Implications	Review of remaining outdated legislation and regulations.
Proposal 2:	**Clarification and Interpretation of Specific Policy and Guidelines**
Strategy Proposal	Several aspects of existing policy require clarification and the development of a common understanding among affected water sector actors. Some of the areas where clarity is necessary are: - RDP standards and the implications of changing or enforcing these. - The role and impact of the Development Facilitation Act in the promotion of local planning and service delivery. - Updated views on transitional roles and functions originally outlined in the White Paper on Water Supply and Sanitation. - Clear definitions of "bulk" and "bulk customers". The forums in which the discussions on the above issues should take place will vary according to the topic (see Lead Actors below).
Current Status	Feedback from communities is showing some dissatisfaction with the RDP service level benchmark of the RDP, and the likely stand of government on this issue is not clear. The DFA is being implemented at local level by some District Councils (eg Rustenburg), but not by all. Emerging views on roles and functions are being discussed in some forums, but conclusions are not necessarily widely shared. The question of the definition of bulk has yet to be resolved in the Study Area
Lead Actors	It is suggested that the following lead actors take responsibility for processes leading to the clarification of the issues listed above: - RDP. DWAF (national and regional), working in regional and area planning forums. - DFA. District Councils. MW and DC to consider jointly the implication of the DFA for the development of bulk services. - Transitional roles. DWAF and District Councils, through regional and area planning forums. - Definition of Bulk. MW and District Councils.
Policy Implications	Greater clarity among water supply implementers.

Proposal 3:	**Integration and Partnership**
Strategy Proposal	It is proposed that a framework and an active plan for sharing information and the integration of activities are established. This plan will examine existing communication instruments and networks, and their effectiveness, and will implement actions to deal with shortcomings. The notion of training, service and support cooperatives should be included in the plan. A priority is an integrated communication strategy.
Current Status	At present two broad frameworks for communication, integration and partnership are crystallising. The first is led by actors in the water sector (notably DWAF), and has an obvious water focus. The second framework centres on local government, and is presently less well developed. In some parts of the Study Area, District Councils are making progress with the institutional development necessary to empower local authorities to deliver a basket of services, in accordance with their constitutional brief. A priority action is to develop and rationalise the links between these frameworks.
Lead Actors	DWAF should continue to lead the development of water sector institutional arrangements, and the provinces and District Councils local government functions. A forum or forums for integrated planning should be developed. The emerging area forums may serve this purpose, but attention must be given to areas where institutional capacity is not present. MW should participate in such forums. MW might also resource and implement its own communication capability and strategy, in concert with the broader initiatives of DWAF, the provinces and the District Councils.
Policy Implications	Water sector development policy seems likely to become much more integrated with policy empowering local government.

Proposal 4:	**Coordination of Training and Training Resources**
Strategy Proposal	Design and implementation of an integrated approach to training and the sharing of training resources. This might include consideration of issues such as the formation of a training cooperative, the implementation of skills and training needs audits, forums to discuss the deployment of human resources, and the effective use of local support structures such as NGOs, LWCs and RDP committees.
Current Status	Training is presently loosely coordinated and often implemented in relative isolation.
Lead Actors	Training needs are so diverse that is not possible to identify a single lead actor. The urgent need is to find frameworks and forums where training needs and actions can be discussed across Study Areas and among various actors. Area planning forums, with inputs from District Councils and DWAF, may serve an initial "brokerage" function. MW should participate in the training discussions, and identify areas where they can offer training. Internal MW training needs are discussed under (10) below. DWAF is well placed to consider programs and resources that might be relevant here, and should continue in this role.
Policy Implications	More integrated and efficient training policy among water sector organisations.

Proposal 5:	**Water Supply and Local Economic and Resource Development.**
Strategy Proposal	The development and implementation of a strategy to link water supply to both local economic development and community institutional capacity building. The key to such a strategy appears to be the entrenchment of planning capacity at local level. Such planning should address the delivery and management of all services, together with the mobilisation of the human resources required to perform and sustain these tasks.
Current Status	Large and well resourced local authorities engage in local development planning. Many of the new local authorities are uncertain of their responsibilities in this regard, and often have no experience or capacity. The Rustenburg District Council is one of the first in South Africa to empower local planning by linking small local authorities, and assigning technical expertise to these "zones". This model is a variant of several possible service cooperative approaches, and should be monitored closely by DWAF and MW.
Lead Actors	The primary responsibility for local development planning should rest with the provinces and the District Councils. DWAF and MW might play a catalytic role in the Study Area by assisting emerging District Councils to explore and evaluate the approaches of bodies like the Rustenburg DC.

Proposal 5:	**Water Supply and Local Economic and Resource Development.**
Policy Implications	The promotion of integrated local planning has substantial implications for policy regarding Third Tier capacity building, and the manner in which the Third Tier tackles its service delivery roles. It seems likely that service cooperatives, with the possible involvement of the private sector (as planning facilitators and service providers) will become more common, especially outside of the resource-rich major urban areas. Among other things, government will have to become clearer on its policy position regarding the contribution of the private sector.
Proposal 6:	**Sharing "Best Practice".**
Strategy Proposal	The development of an approach and vehicle/ vehicles for the sharing of best practices (and information). As the transitional process unfolds, it is certain that innovative and effective approaches to issues like cost recovery, local incentives, payment systems, local financing, and locally managed operations and maintenance will be developed. The strategy is to ensure that these initiatives and experience are shared.
Current Status	Effective management and operational solutions are sometimes unrecognised by a wider group who might benefit from them.
Lead Actors	The most effective forums to discuss and explore best practice are those where both water delivery and local government administration are on the agenda (eg area planning forums). Lead actors might be District Councils and DWAF. MW should contribute actively to the forums wherever possible. DWAF should also consider ways to share best practice nationally. This is work that might be done by an appropriate NGO.
Policy Implications	Best practice will make a contribution to operationalising policy, and to the development of practical and tested guidelines.
Proposal 7:	**Development of New Markets/Bulk Customers.**
Strategy Proposal	It is seen to be important that MW clarifies its own position on three forms of Third Tier support: • Project implementation and "emergency" Third Tier support where the relevant local government structures do not exist. • Forms of support to wider Third Tier capacity building. • The development of new bulk customers and markets. The first form of Third Tier support is essentially short-term, and will apply where capacity does not exist. Issues to be considered are the terms of MW engagement and the timing and nature of handover. The development of new bulk markets is a long-term activity that will include aspects of Third Tier capacity building. Issues requiring attention in the context of the development of bulk markets are: determining the nature of Third Tier support required to empower effective future bulk customers; the development of a classification of emerging bulk customers, with the type of support required for each category; the preparation of cost recovery forecasts and targets, and the development of appropriate capacity to interact with emerging bulk customers.
Current Status	MW is already involved in short term project implementation, but has frequently articulated the need to clarify this involvement and other forms of Third Tier support.
Lead Actors	MW is the lead actor in this context, but the proposed strategy will require discussions with DWAF and elements of the Third Tier (especially District Councils, and possibly area development forums).
Policy Implications	The positions adopted by MW will assist in clarifying WB roles as broadly described in the White Paper on Water Supply and Sanitation.
Proposal 8:	**Perceptions of Water Boards**
Strategy Proposal	Develop a strategy to build a constructive perception of water boards (and especially MW) in the Study Area. This activity links to the development of bulk markets outlined above, and would seek to create a sense of "ownership" among local authorities and communities in the Study Area.

Proposal 8:	**Perceptions of Water Boards**
Current Status	It is evident from the work of DWAF (and agencies like BODA) in the various provinces that communities are unfamiliar with the role played by Water Boards. In some areas, local authorities are concerned with what they perceive to be a parallel bureaucracy.
Lead Actors	MW is the lead actor in this context, but will have to work within the framework of Third Tier institutions and protocols. BODA will be a useful source of technical advice.
Policy Implications	The strategy is entirely in line with the broader policy of promoting Water Boards as key actors in the water supply chain.
Proposal 9:	**Systems and Key Processes**
Strategy Proposal	Investigate and develop key processes and systems that will assist in the effective supply and management of water at local level. Issues that might be given attention include prepaid metering, basic water related accounting, community and private-sector based collection systems, and local financing systems for higher levels of service. This strategy might be carried out in conjunction with the "best practice" strategy discussed above.
Current Status	Many processes and systems are already in place, but have not been fully evaluated.
Lead Actors	The discussion of "best practice" might take place in the forums discussed above. MW (in discussion with the District Councils and DWAF) might then select initiatives worthy of support in terms of its Development of New Markets strategy.
Policy Implications	Tried and tested processes and systems might be more widely adopted in due course.
Proposal 10:	**Appropriate Structuring of MW.**
Strategy Proposal	Develop a structure proposal for MW in the Extended Supply Area which addresses short, medium and long term needs, and MW's role vis-à-vis other players in the water and local government sectors. Issues that will shape the structure proposal include: - The priority and technical and financial feasibility of resource and infrastructure development (this will influence decisions about expanding technical, financial and operations and maintenance capacity in MW). - The present and anticipated future pace of development of the Third Tier (this will influence the view taken on capacity for "emergency" assistance). - The nature of the selected long term Third Tier support strategy (especially with reference to the strategy to develop new bulk markets). This will influence decisions about communication/ interaction capacity and capacity for targeted Third Tier capacity building. It may also have a bearing on decisions regarding the nature and representativeness of the Board. - The short and long term capacity of present management and organisational structures in the context of the extension challenges (extending supply and providing support). - The short and long term resolution of issues relating to the definition of the supply area boundary (eg the Water Board option selected by the KwaNdebele Water and Sanitation Task team, and the finalisation of long term options around present supply agreements with Rand Water). - Links between spatial units based on water management criteria and those formed by local government structures for area planning and local administration purposes. In this context, avoiding the duplication of capacity is an issue. With these issues in mind, MW may have to reconsider the present structure of the organisation, possibly extending operations and maintenance functions, placing these in modified spatial and management contexts. It might also wish to build a market development arm, with additional organisational implications.
Current Status	MW is an effective and efficient organisation in the context in which it currently operates. In addressing the new challenges, MW and its Board will wish to retain these qualities.

Proposal 10:	Appropriate Structuring of MW.
Lead Actors	Decisions around organisational structure are the jurisdiction of MW and its Board. This is confirmed in the Scope of Work agreed between the governments of South Africa and Japan.
Policy Implications	MW decisions regarding the appropriate structure of the organisation might assist other Water Boards to structure their response to the challenges of transition and beyond.

Proposal 11:	Redeployment of Resources to Create Capacity
Strategy Proposal	Magalies Water recently absorbed about 350 staff from NWWA as a result of the extension of MW's supply area. A preliminary assessment by MW indicates that through effective structuring and use of technology it is possible that current water supply function in former NWWA areas might be undertaken by 300 people. This creates the possibility of reallocating about 50 people. It is proposed that these people be trained and then used strategically to strengthen the Third Tier. Ultimately they may be transferred to relevant local authorities. Possible functions for relocated staff are: - Effecting connections. - Meter reading. - Collections. - Problem solving and liaison. - Minor repairs.
Current Status	MW has recently taken these staff on and is assessing operational requirements in the extended supply area. The assessment will confirm the feasibility of this proposal. Areas of redeployment have not been identified, and training needs have not been assessed.
Lead Actors	MW should lead the process in consultation with Third Tier actors in the areas selected.
Policy Implications	Policies and processes regarding the transfer of staff between institutions will be clarified.

Table 3-3: Initiating Ongoing Planning and Coordination

Process Step		Timing
1.	Acceptance of recommendations	November 1996
2.	Formation of coordinating forum	November 1996
3.	Forum meets to commence planning	February 1997
4.	Task groups work on the plan	February-March 1997
5.	Forum meets to review, revise and endorse critical path	March 1997
6.	Coordination and follow-up meetings	1997 and 1998

Figure 3-1 : The Gap Analysis and Policy and Strategy Processes

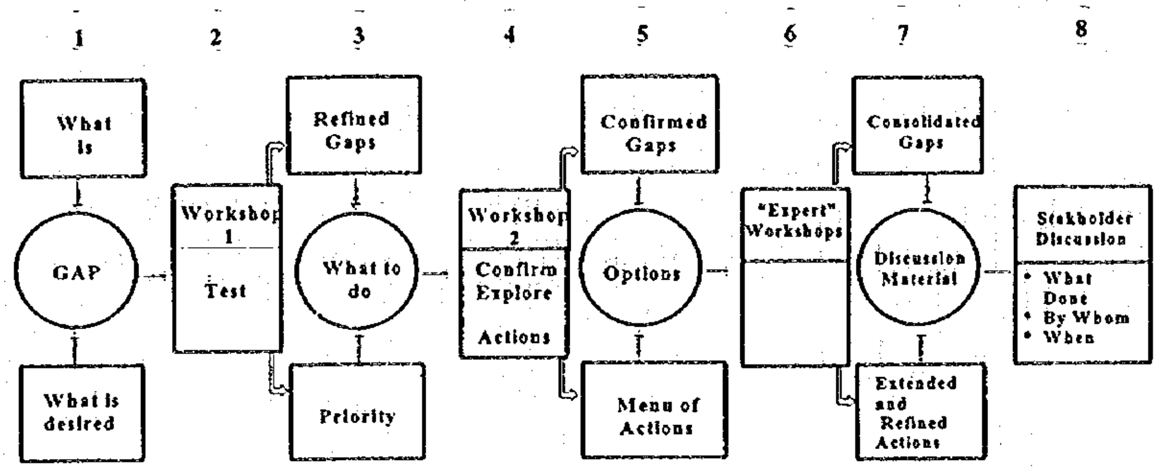


Figure 3-2 : Linkages Between Gaps

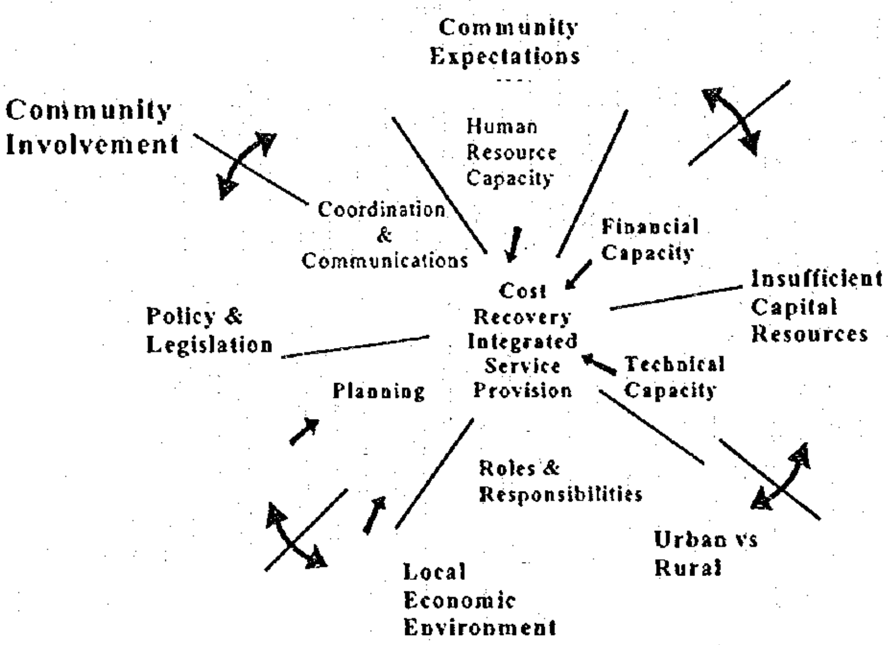


Figure 3-3: Elements of an Initiating Framework

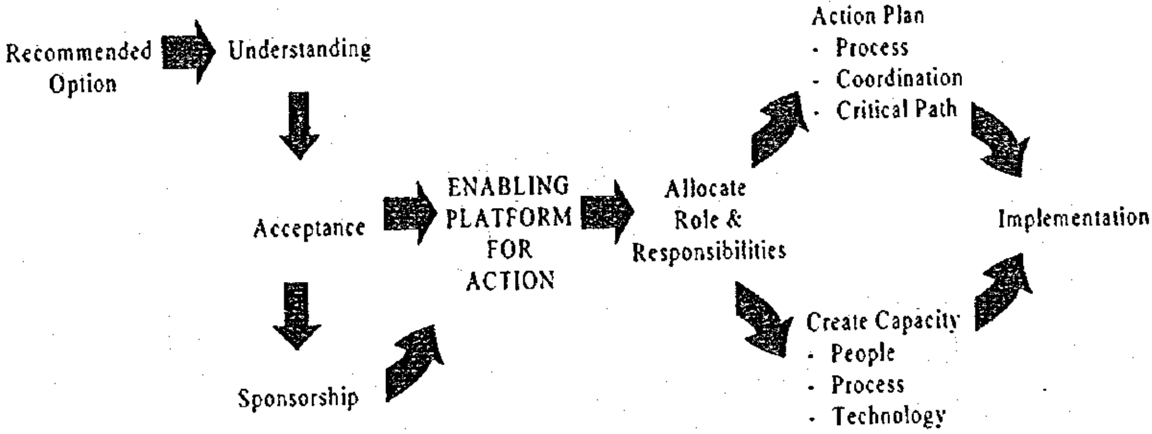
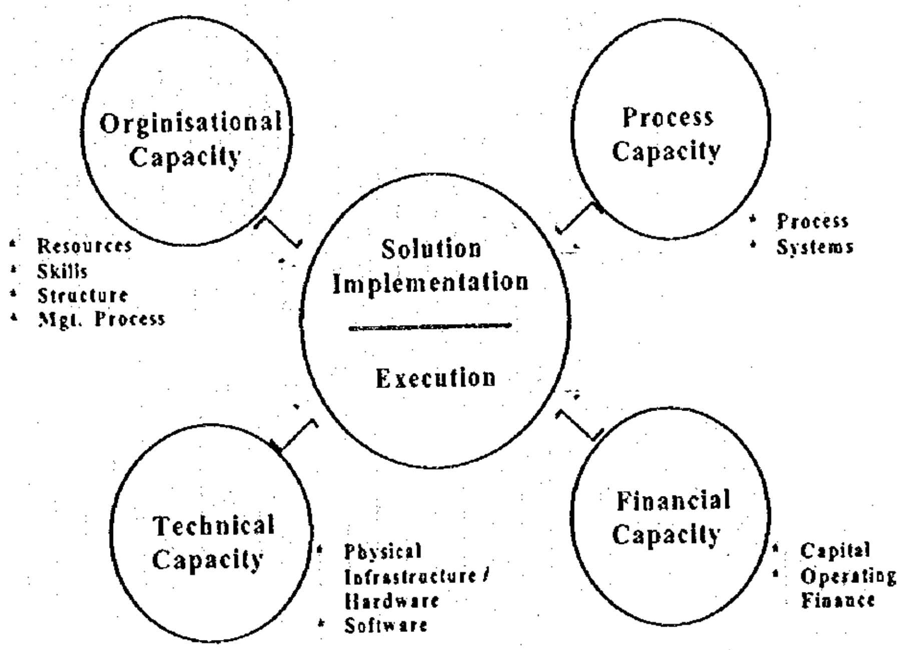


Figure 3-4: Components of Capacity



CHAPTER 4 WATER DEMAND AND SOURCE OF SUPPLY

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CHAPTER 4 WATER DEMAND AND SOURCE OF SUPPLY

4.1 Zoning of Study Area

4.1.1 Purpose and Basic Concept

The JICA Study Area was divided into a hierarchy of spatially identified supply areas. From the largest to the smallest division these have been termed Supply Zones, Supply Areas and Supply Blocks. The purpose of these groupings was to serve as a basis for the arrangement of water demands and supply sources, as well as for the management of water supply schemes within the Study Area.

The division of the JICA Study Area that was finally adopted in this Study is shown on the Location Map and is also summarised in Table 4-1.

4.1.2 Supply Zone/Area/Block

The criteria that were applied when grouping primary demands and infrastructure into Supply Zones, Supply Areas and Supply Blocks are set out in (1) to (3) below:

(1) Supply Zones

A Supply Zone comprises a grouping of bulk demands that are served by one management unit of Magalies Water, or an expected future management unit of the Board.

Three Supply Zones were selected in this Study, viz a Western, a Central and an Eastern Supply Zones. These Supply Zones were selected primarily to accord with the natural drainage system of the Study Area. As mentioned elsewhere, the Study Area comprises basically two main river drainage systems. Those are the Olifants River system in the east and the Crocodile River system in the centre and west. Existing water supply infrastructure has for obvious reasons also been developed around this natural drainage system.

The Western Supply Zone is supplied with water from four sources, ie the Elands and Crocodile Rivers, via the Vaalkop Dam, and the Hex River from the Bospoort Dam. A large volume of primary water is also imported into the Study Area at Barnardsvlei by Rand Water (Vaal River System).

The Central Supply Zone has four primary water sources, ie the Pienaars River (Roodeplaat Dam - Wallmannsthal and Temba Treatment Works, and the Klipvoor Dam - no existing treatment works), Apies River (Leeukraal Dam - Kudube Treatment Works), the Crocodile River (Hartbeespoort Dam - Brits Treatment Works) and the Vaal River (imported by Rand Water for supply to the Akasia, Rosslyn, Klip-Kruisfontein, Ga-Rankuwa, Mabopane and Shoshanguve areas).

The Eastern Supply Zone has three separate supply sources, all being tributaries to the Olifants River, ie the Bronkhorstspruit (Bronkhorstspruit Dam and Treatment Works), the Wilge River (Premier Mine Dam - Cullinan Treatment Works) and the Elands River (Mkombo Dam - Weltevreden Treatment Works). Water is also imported from the Loskop Dam (Olifants River) for purification at the Weltevreden Treatment Works. Proposals have also been approved for the transfer of Vaal River water from the Grootdraai Dam into the Bronkhorstspruit Treatment Works.

(2) Supply Areas

A Supply Area comprises a grouping of bulk demands that are supplied from a common surface water resource or a set of resources, eg dams and/or weirs, but allowing also for imported and exported water.

Based on this concept, each of the above three Supply Zones was further subdivided into a number of Supply Areas. Ten Supply Areas were finally established within the Study Area. The Western Supply Zone was subdivided into four Supply Areas, viz the Vaalkop North, Vaalkop South, Barnardsvlei and Koster Supply Areas. The Central Supply Zone was also subdivided into four Supply Areas, viz the Brits, Klipvoor, Temba and Rand Water Supply Areas. The Eastern Supply Zone was only subdivided into two Supply Areas, viz the Bronkhorstspruit and the Weltevreden Supply Areas.

(3) Supply Blocks

Some of the above Supply Areas have further been subdivided into a number of Supply Blocks. A Supply Block comprises a grouping of bulk demands that are supplied from a single bulk supply pipeline (with branched if applicable). The bulk supply pipeline either originates from a water treatment works, or is a branch to a pipeline serving an entire service area that originates at such a water treatment works. In conclusion, the Study Area was divided into 28 Supply Blocks as summarised in Table 4-1.

4.2 Population Projection

4.2.1 Basic Approach

Since 1990 South Africa has seen unprecedented demographic shifts in the population arising from migration away from rural areas and rapid migration into the urban centres and surrounding peri-urban areas. The Study Area, located immediately adjacent to the PWV area which is the economic heartland of the country, has been directly impacted by these changes. Some studies indicate that population growth rates in recent years have been as high as 26 % per annum in some peri-urban settlements.

In the Urban Development Strategy and the Rural Development Strategy published in the Government Gazette in November 1995 it was forecast that 75 % of the national population will be urbanized by the year 2020 (compared to the present level of 38 %).

DBSA also views that the movement of population to metropolitan and other urban areas can be expected to continue, and that the rural population will probably not increase and may even significantly decrease.

For the JICA Study it is envisaged that whilst movement of the rural population from outside the Study Area to Soshanguve, Wonderboom, Brits, Moretele 1 and Odi 1 will continue, less significant numbers of the rural population living within the Study Area will move out to the PWV and to other urban areas. The overall growth rate of the population in the Study Area will therefore remain slightly higher than the national natural growth rate which is 2.3 %.

(1) Population Baseline Data

For the purpose of the population projection, data from existing information sources was collected and captured in a database. To obtain Study Area wide settlement specific population data, the following sources were referenced :

(a) 1991 Census of South Africa and Bophuthatswana

(b) 1993 NELF database

(c) 1994 DBSA database

(d) 1995 CDE database

Although ad-hoc settlement specific population studies have been undertaken in the Study Area, they are insufficient to build-up an overall picture for the Study Area.

As the NELF, DBSA and CDE databases were all constructed from 1991 census statistics, the 1991 census data was also adopted for the JICA Study as the best available Study Area wide settlement specific population baseline data.

(2) Consolidated Database of Population

From the above information sources, a consolidated database of comparative statistics by settlement was compiled (see Part A-1 of the Data Book) for cross-reference purposes. Data was collected by magisterial district for the twenty districts in the Study Area, which are located in four provinces, namely North-West, Mpumalanga, Gauteng and Northern.

(3) 1995 Population

Since it is impractical in a macro study to derive population growth variables for each and every settlement, the Study Area was divided into seven socio-economic/physiographic zones comprising areas which display similar development characteristics, viz (i) Mpumalanga (Moutse 1 and 3, Moretele 2, Mdutjana, Mkobola, Mbibana, Kwamhlanga), (ii) Bronkhorstspruit - Cullinan, (iii) Nylstroom - Warmbaths - Waterberg, (iv) Brits - Odi 1 - Moretele 1 - Wonderboom - Soshanguve, (v) Mankwe - Bafokeng - Odi 2 - Rustenburg, (vi) Swartruggens - Koster and (vii) Thabazimbi.

For each of these seven zones, settlement conditions and recent dynamics were explored as the basis for deriving growth rates to update the baseline population to obtain a best estimate of the 1995 population. An overview of the growth scenarios adopted for each zone is described in Section 4.2 of Supporting Report B.

(4) 2015 Population

Based on consultation with local officials, (see Part A-3 of the Data Book for a list of officials interviewed), and a review of development planning documents relevant to the Study Area and its immediate surroundings, future growth scenarios were developed with associated population growth rates up to the year 2015. Those scenarios are also discussed in detail in Section 4.2 of Supporting Report B. In essence, the following growth scenarios are foreseen for the Study Area for the forthcoming 20 years :

(a) The primary population growth will take place in Pretoria - Ga-Rankuwa, Mabopane and Temba areas.

(b) A secondary growth area is that of Rustenburg with a growth axis extending up to Monakato - Mogwase - Northam - Thabazimbi.

(c) The densely settled areas of Moutse and Kwamhlanga do not possess the underlying sustainable growth factors found in the above two areas.

(d) The dormitory villages in the area west of the Pilanesberg, northern and central Odi 1 and Moretele 1, and Moretele 2 will merely retain their present status.

(e) Growth prospects are poor for the Swartruggens - Marico - Koster area.

(f) The rural area east of Pretoria and north of Bronkhorstspruit, (ie: Cullinan - Rust de Winter), is likely to remain as an extensive agricultural area.

4.2.2 Projected Population

In line with the above spatial growth scenarios the 1995 population in each community in the Study Area was further projected for the year 2015. Table 4-2 summarises the projected population for each supply block, supply area and supply zone with a breakdown according to service mix and level of service (see Appendix 1 to Supporting Report B for more detailed information).

4.3 Water Demand Projection

4.3.1 Basic Concept

Water demand has been estimated in this Study for the following two major purposes:

(1) To use for water balance study to assess the availability of local water resources; and

(2) To use for planning of primary water supply infrastructure.

It should be noted that water demands used in the water balance study are those which were available at an early stage of the water demand projection, and they are not exactly the same as those obtained as the final outcome of the water demand projection which have been used for infrastructure planning. Nevertheless, it does not invalidate nor significantly affect the results of the water balance study as far as water demands used in the study are slightly greater than those used for infrastructure planning.

Water demand was estimated separately for its two major components, viz primary water demand and non-primary water demand. Primary water demand has been estimated for each of its elements, viz domestic, industrial, commercial, institutional and mining water demand. Non-primary water demand has also been estimated for each of its elements, viz agricultural, stock-watering, environmental and international river flow requirements.

4.3.2 Primary Water Demand

(1) Domestic Water Demand

No reliable primary statistics of household income and expenditure exist from which affordability of level of water supply can be directly addressed. Findings of previous village water supply schemes and studies in the Study Area were used to assess water demand profiles in typical villages.

Communities in the Study Area were categorized according to the following basic criteria:

(a) established urban towns fully serviced with little or no informal infill;

(b) formal towns with informal infill;

(c) peri-urban villages with influx growth;

(d) villages with bus route commuter links; and

(e) distant, subsistence level villages with negative or no growth.

Based on the findings of previous studies, actual water demand was estimated using a ratio of house connections, metered yard taps and street taps for each of the above categories.

(a) 100 % house connections for traditional towns fully serviced with little or no informal infill;

(b) 75 % house connections, 15 % yard taps and 10 % street taps for formal towns with informal infill;

(c) 75 % house connections, 15 % yard taps and 10 % street taps for peri-urban villages with influx growth;

(d) 20 % house connections, 60 % yard taps and 20 % street taps for villages with bus route commuter connections.

(e) 5 % house connections, 15 % yard connections and 80 % street taps for distant subsistent villages with negative or no growth.

It was also found from previous studies that :

(a) for peri-urban/rural areas, the per-capita water demand associated with each level of service, (exclusive of system leakage losses), is as follows :

House connection: 120 lcd
Yard tap : 70 lcd
Street tap : 30 lcd

(b) for formal towns with informal infill the per-capita water use for house connections could be as high as 230 lcd;

(c) for established urban areas the per-capita water use for house connections is much higher than 230 lcd and varies from place to place.

Using the above community classification and the per-capita water demand, five mixes of levels of service have been developed as shown in Table 4-3. A mix of level of service was then selected for each individual community in the Study Area for 1995, 2002 and 2015. Thus, from the projected population and mixes of level of service, domestic water demand for 1995, 2002 and 2015 was estimated for each community.

(2) Non-Domestic Water Demand

(a) Industrial, Commercial and Institutional Water Demands in Urban Areas

In established urban areas, a significant portion of water is used for industrial, commercial and institutional purposes. In a detailed study of water use in Rustenburg, industrial demand was found to comprise about 20 % of that for domestic use, with commercial and institutional elements comprising 15 % and 10 % respectively. Where separate figures were not available, the split has been assumed to be as indicated above.

(b) Water Demands for Mines and Other Special Industrial and Commercial Centres

Water demands for mines and other special industrial and commercial centres were either studied separately on an actual consumption basis or, where large consumers are currently being supplied by water boards, demand figures were obtained directly from MW or RW.

(3) System Leakage Losses

It was assumed that the water supply system will be upgraded in the future and so a reduction in system leakage losses from the system will be achieved. An allowance of 20 % for system leakage losses (between the outlet of water purification works and end consumers) was added to the primary water demand estimated for the year 1995 and this was assumed to decrease to 18.25 % by the year 2002 and to 15 % by the year 2015.

Other components of unaccounted-for water, such as losses due to meter malfunctioning, meter under registration and illegal connections were assumed to constitute a portion of water consumed therefore are included in the per capita consumption figures, so no separate allowance was added to the primary water demand to allow for these losses. Table 4-4 summarises the projected primary water demand for each Supply Block, Supply Area and Supply Zone with a breakdown according to water use category (see Appendix 1 to Supporting Report B for more detailed information).

4.3.3 Non-primary Water Demand

Elements of the non-primary water demand comprise irrigation demand, stock-watering demand, and environmental and international river flow requirements. These are discussed as follows:

(1) Irrigation Water Demand

Irrigation is one of the biggest water uses in the country and is therefore a major factor in present and future water resource management in the Study Area.

Many variables such as irrigation efficiency, irrigation technology, type of crops irrigated and crop management affect irrigation demand.

Irrigation in the Study Area is supplied from two sources, namely:

(a) Surface water sources (dams, canals, rivers); and

(b) Groundwater sources (boreholes).

These two major sources can be further sub-divided, from a management view-point, into areas which are subject to Government water control and those which are subject to the provisions of the Water Act.

Most of the major storage dams in the Study Area were originally built mainly for irrigation purposes. In a number of cases their use has changed and some of the water is now used for domestic or industrial purposes. Most, if not all, minor dams (farm dams) are privately owned and were built for irrigation, for soil conservation purposes, for stock-watering or aesthetic reasons.

In most cases major dams are located in a Government Water Control Area (GWCA) and form part of a Government Water Scheme (GWS) from which water is allocated by the Minister of Water Affairs and Forestry for irrigation and for other purposes. Irrigation Boards (IB) are formed to manage the allocation of water from Government Schemes or from their own works. Irrigated land is scheduled either under a GWS or an IB.

Water for irrigation is usually released from a dam into the river or into a canal system from which the irrigators abstract their quota. Many of the minor dams in the Study Area were built for augmenting allocations from major schemes, particularly during drought periods when allocations from major dams are restricted. Irrigators also make use of balancing dams for storing water abstracted from a canal or river. They then irrigate on demand from these dams. Private irrigation is not scheduled as described above and is usually served directly from a river.

Water demand for irrigation has been evaluated by sub-catchment and in respect of GWS, IB schemes and private irrigation schemes. The total demand is 441.6 mcm/a, of which 55%, 8% and 37% are the respective proportions for GWS, IB and private schemes. It is expected that the future demand will remain at the current level. A summary of the estimated water demand for irrigation is given in Table 4-5.

(2) Stock-Watering Demand

In the Study Area, there are large areas of grazing land for livestock breeding. One representative large stock unit is equivalent to one head of cattle, six sheep or goats, twelve pigs or one hundred chickens. The average daily water requirement for a large stock unit is about 50 litters.

The total population of equivalent large stock units in the Study Area is estimated to be 458,000. The total estimated present stock-watering requirements is thus 8.36 mcm/a. Since livestock is part of the survival strategy of many impoverished communities in rural areas, and since stock-keeping plays an important role in tribal culture, stock-watering requirements cannot be ignored in the assessment of primary rural water demand. It is assumed that the stock-watering demand will remain at the current estimated level of supply.

(3) Environmental and Other Requirements

The water balance simulation model used for the Study is set up to simulate the behavior of the system when required to satisfy a specific set of water demands for primary use and irrigation. Other important water requirements are for sustaining in-stream ecosystems and for satisfying international river flow commitments.

Riverine ecosystems and other water requirements for environmental purposes do not enjoy legal recognition under present legislation and the existing water resources development was generally planned without specific provision being made for these aspects. Consequently the actual in-stream flow requirements of the rivers in the Study Area are not quantified.

Since environmental water requirements are generally non-consumptive, and a significant portion of irrigation water requirements are abstracted directly from the river, the water balance simulation does not include specific provision for environmental purposes.

All of the rivers in the Study Area are of interest to one or more neighboring states and are subject to international rules for best joint utilization as originally codified in the 1966 Helsinki Rules. Although discussions on the development of international rivers have taken place between RSA and the co-basin states, the river regime required at state boundaries has not been quantified. A simplified assumption was made that the residual flow in rivers, including flow to sustain ecological systems, would satisfy inter-state obligations and that new development proposals would be discussed with neighboring states before implementation.

4.4 Water Balance Study

4.4.1 Basic Approach

(1) Water Balance Simulation Model

The model used to simulate the behavior of the Crocodile River and Upper Olifants River systems was the Water Resources Yield Model (WRYM) developed for DWAF over a long period of time.

The WRYM is a general, multi-purpose, multi-reservoir simulation programme which can represent virtually any water resource system incorporating the usual processes such as runoff, rainfall, evaporation, storage and release of water from reservoirs, inter-basin transfers and losses. The model can accommodate a wide range of operating policies using a complex penalty structure to govern the allocation of water from sources.

The WRYM works on the assumption that a water resources system can be represented by a flow network. By careful selection of penalty structures, the network can be analyzed for each time period using an efficient network solver which has been evolved from network programming techniques.

The special structure of the network optimization technique used in the WRYM, achieves an "optimal" solution to a water resources allocation problem faster than traditional linear programming formulations and with less round-off error.

In order to use the WRYM effectively it is necessary for the user to describe the physical system as a network schematic consisting of discrete components, each represented separately in the model. Junction and control points such as reservoirs are represented as nodes while natural or man-made flow paths that connect the junctions are referred to as channels.

The naturalised flow is derived from the recorded flow at a gauge by estimating all factors affecting the flow and taking them into account for the full period of recorded data. The resultant naturalised flow is the flow which would have occurred had there been no developments within the catchment area. Factors which must be taken into account include all man-made effects (ie. irrigation, industrial abstraction, etc), as well as storage, evaporation, rainfall and all water losses.

The monthly irrigation requirements are usually based on current development levels applied. When used together with the naturalised flow files, they enable stochastic sequences to be generated that are consistent with current development levels. The irrigation water requirement as used in the water balance study refer to the demand from existing irrigation, which is not supported by significantly large reservoirs (farm dams) or major dams within the catchment. The irrigation requirement is taken directly from the natural flow and has, therefore, first priority to the available natural flow.

(2) Assumptions and Level of Security of Supply

In the water balance simulation, in order to simplify the assessment of water supply assurance, the users with similar characteristics were grouped together so that where it is necessary to restrict users due to limited water resources, similar limitations can be applied to similar user groups.

From previous studies undertaken by DWAF, it was determined that a flexible approach should be used, depending on the user group, as to the amount of restrictions that can be imposed. In the case where a user places a high premium on assured supply, a large portion of supply must be at a high assurance level.

Assurance of supply is expressed in terms of "return period" which indicates how often the demand might not be fully supplied.

The user group divisions and associated return period used for the JICA Study were those applied in a previous study, "Crocodile River, Western Transvaal Catchment Study, March 1993", and are tabulated in Table 4-6. The figures indicate that for the urban user group, only 20 % of the demand can be curtailed once every twenty years (1:20 year return period). A further 30% may be curtailed at a frequency of once every hundred years and that 50% must be available at 1:200 years.

Table 4-7 summarises the water demands for each user group assumed in the years 1995 and 2015 for the purpose of the water balance model. It should be noted that as the process of assuming a distribution of demands, assessing whether these can be met from the water resources and then adjusting the split accordingly, is an iterative process, the model would ideally be rerun with the final demands. However due to time constraints and the small improvement in accuracy achieved by rerunning the model, this was not carried out. As a result of this, and also due to refinement of the water demands during development of the infrastructure proposals, the demands used for the water balance model do not exactly coincide with those used for the infrastructure planning. The demands have generally decreased slightly and so those used for the model were a worst (and therefore safe) case.

4.4.2 Available Water Resources

(1) Surface Water

Utilization of streamflow in the Study Area has been developed to the extent that large storage dams have been constructed on virtually every main river to regulate the variable runoff to meet increasing water demands.

Within the Study Area, ninety storage dams have been identified. Twenty two of these have a capacity of 1 mcm or more, and a combined storage capacity of 842 mcm. Total storage capacity of all dams in the Study Area is about 909 mcm. Most of the major dams and virtually all of the minor farm dams were built for irrigation purposes. Water supplies from some of these dams were later reallocated for domestic use only but irrigation still predominates as a water use sector.

Probable naturalized drought runoff for specified points on the Crocodile and Olifants rivers is tabulated in Table 4-8.

(2) Expected Return Flow and Incremental Urban Runoff

The major contributors to return flows in the Crocodile River basin are the municipal and industrial sectors. Since most of the water for urban water supply is imported from adjacent river systems, these return flows have, in the recent past, effectively constituted an inter-basin transfer importation of water which has supplemented the natural runoff. In order to evaluate such return flows which represent an important water resource in the basin, DWAF commissioned a study on the "Urban Demands and Return Flows in the Crocodile River Catchment" (CRCS), in August 1990. The conclusion of the study was that the return flow from major sewage treatment plants in the Upper Crocodile sub-system will comprise about 59% of the total quantity of water supplied in urban areas by the target year 2015.

Since the results of the CRCS were originally published, environmental conditions in the river basin have changed slightly so it was necessary to update the conclusions. In June 1996, DWAF in cooperation with BKS, executed a study to determine optimum operating rules for the transfer of water from Hartbeespoort Dam to Vaalkop Dam and to address concern regarding possible over estimation of return flows as well as urban water demand projections. The average return flow ratio, estimated from this further study, was about 53%. In addition, incremental surface runoff due to urbanisation was considered to be about 45 mcm/a in the specified areas.

The summarised return flows and urban runoff to be applied in this Study are shown in Tables 4-9, 4-10 and 4-11.

(3) Groundwater

The hydro-geology of the Study Area is described in Section 2.1.6 of the Main Report and Section 5-12 of Supporting Report B.

Groundwater resources in the Study Area are utilized for potable water supply to rural communities, stock-watering, irrigated agriculture and for urban water supply (to a limited extent). It is difficult to quantify the volume of groundwater abstracted for potable water supply to rural communities and for stock-watering.

With regard to irrigated agriculture, more reliable figures are only available in some areas. Farm land located along the lower reaches of the Crocodile River is irrigated using borehole pumps for drawing water from the relatively high-yield aquifer. The water abstracted is replenished by water from the river system.

Groundwater quality in the Study Area is divided into the following three categories according to the DWAF classification, from the view point of primary use.

(a) Class 0 / 1:

Ideal water quality (suitable for lifetime use), or good water quality, (rare instances of negative effects);

(b) Class 2 :

Water safe for short-term use only, (common instances of negative effects with long term use); and

(c) Class 3 / 4:

Water quality unacceptable for domestic use. (unsuitable for domestic use without treatment, and possibly also unsuitable for stock-watering purposes).

The development policy proposed for groundwater use for primary water supply in the Study Area, is that utilization of groundwater should be restricted to Class 1 in the target year 2015, except for primary water supply to remote areas where groundwater is the only available water source or where a surface water supply is economically unfeasible. In addition, boreholes that were previously used for abstracting groundwater should be kept available for emergency use during drought periods.

Utilization of groundwater in the Study Area, therefore, is assumed to decrease according to the plan shown in Table 4-12.

The amount of surface water required to meet the projected primary water demand that were assumed in the model are shown in Table 4-13.

(4) Rand Water

At present Rand Water supplies 42.1 mcm/a of water into the Central Zone of the Study Area via Hartbeeshoek Regional Reservoir, and 39.3 mcm/a into the Barnardsvlei area in the Western Zone. For the water balance study, the amount of water available from these Rand Water systems in 2015 was assumed to be restricted by the capacity of the existing infrastructure. The Hartbeeshoek system has recently been strengthened to give a total capacity of 86.9 mcm/a, but the Barnardsvlei system already operates at the existing maximum capacity of 39.3 mcm/a. The assumptions concerning the level of the Rand Water supplies for each part of the water balance study are shown in Table 4-14.

4.4.3 Water Balance Simulation

(1) General Description

In order to assess the adequacy of the limited water resources in the Study Area, the following water balance simulations were carried out to compare water availability from river runoff and return flows from urban areas, with the water demand (excluding that met from groundwater).

The cases and concept of the water balance simulation in the Study are represented by the following three cases:

(a) Case 1:

To simulate the water balance between existing available water resources and the water demand in 1995.

(b) Case 2:

To simulate the water balance between existing available water resources and water requirements in 2015.

(c) Case 3:

To simulate the water balance between existing available water resources plus newly developed water resources, and water demand in 2015.

Since the Case 2 study mentioned above indicated that the water demand in the target year can just be met using the existing available water resources infrastructure, three alternative studies were proposed for Case 3 (instead of the original scenario). These were:

(a) Alternative 1:

In the case of water imported from Rand Water remaining at the level supplied in 1995 (42.1 mcm/a for Central Zone and 39.3 mcm/a for Western Zone).

(b) Alternative 2:

In the case that the maximum amount of water imported from Rand Water is at the same level as assumed in Case 2 (86.9 mcm/a for Central Zone and 39.3 mcm/a for Western Zone),but expected return flow in the year 2015 is decreased to 80% of the return flow originally projected.

(c) Alternative 3:

The concept of this alternative was the same as Alternative 1 but with the water allocation modified.

(2) Simulation and Assessment of Case 1

In the present situation the existing water resources infrastructure can easily cope with the primary water demand at the postulated level of assurance. For irrigation there are cases where the irrigation falls below the postulated levels of assurance but these have been previously selected and accepted by the relevant irrigators. Example include irrigators from Olifantsnek Dam and from Swartruggens Dam.

The major influence on the high levels of supply is the significant quantity of return flows into the area. For the present conditions this amounts to some 120 mcm/a in the Upper Crocodile and 89.5 mcm/a in the Pienaars and Apies catchments. Table 4-15 indicates the demands and the amount available for supply for both irrigation and primary water demand for each water resource. These figures are average annual values.

(3) Simulation and Assessment of Case 2

Case 2 represents the base case in the target year 2015 and it is assumed that the existing primary water supply from Rand Water to the Study Area will increase in the future, but only up to the capacity of the existing infrastructure (86.9 mcm/a for Central Zone and 39.3 mcm/a for Western Zone), and that any demand exceeding this capacity will be met using local water resources.

The summary of the simulation for Case 2 is tabulated in Table 4-16, and the water allocation plans on existing and already programmed water source facilities are illustrated in Figures 4-1, 4-2 and 4-3. The results of the comprehensive assessment of the Case 2 simulation are summarised as follows;

As a general trend of the Case 2 study, it can be noted that the incremental return flow from the Crocodile River sub-catchment is about 188.7 mcm/a or 85 % of the 1995 level.

The impact of this, therefore, will contribute greatly to improve the water resources availability in the Study Area.

The assumed irrigation water requirement does not change between 1995 and the target year 2015. The difference between Case 1 and Case 2, therefore represents the balance of incremental primary water demands, increasing available water resources from return flows and imported water from Rand Water, the incremental amount of which is about 44.8 mcm/a.

It is concluded from Case 2 that the primary demand is fully supplied and the water supply for irrigation is also improved, due to the expected significant increase in return flows in the Upper Crocodile and Pienaars river systems. In fact water for irrigation will be supplied at a much higher level than is normally the case in South Africa. In the Olifants River tributaries, the primary demands can also be fully supplied with the incorporation of the already approved importation from Grootdraai Dam on the Vaal River.

(4) Simulation and Assessment of Case 3

(a) Case 3 - Alternatives 1 and 3

Two alternative scenarios were analysed for 2015 based on the base case, i.e. Case 2. Only changes in the Western Zone and Central Zone were modelled. In both alternatives, it was assumed that the present level of water importation by Rand Water would not increase.

In Alternative 1 it was assumed that any shortfall in the Western Zone would be supplied from Vaalkop Dam and shortages in the Central Zone would be distributed equally between Hartbeespoort and Roodeplaat/ Leeukraal dams. The results for this scenario indicated shortages in the irrigation supply at Hartbeespoort and Roodekoppies dams. Furthermore, since short term shortages in the irrigation supply are, in any case expected around 2000, this option is not considered feasible.

The allocation of shortages was then changed in Alternative 3 so that 25% is supplied from Hartbeespoort Dam and 75% from Roodeplaat/ Leeukraal. Shortages at Hartbeespoort Dam are minimal but the level of irrigation supply at Vaalkop Dam reached a level similar to the 1995 scenario. The exact distribution of allocation should be optimized but, from a subjective evaluation of the results, it is likely to be a 30/70 split. This would still not adversely affect irrigation at Hartbeespoort Dam while the supply at Vaalkop would be somewhat increased resulting in an improvement on the present situation. Results of the demand and supply are summarized in Table 4-17 and 4-18 for Alternatives 1 and 3 respectively.

(b) Case 3 - Alternative 2

In Alternative 2 of Case 3, it is assumed that return flows to the catchment will only be 80% of the present estimates. From the results of Alternatives 1 and 3 it is clear that no additional demand can be placed on Hartbeespoort Dam in the short term. The expected shortages in the Rand Water Supply Area in the Central Zone were therefore allocated to Leeukraal while the shortage in the Western Zone was allocated to Vaalkop.

The results indicate that the primary demands can all be met but that there would be a reduction in irrigation supply compared to Case 2. This is still, however, at a slightly higher level than at present (Case 1). Results showing the demand and supply are given in Table 4-19.

(5) Conclusions of the Water Balance Study

In conclusion it was found that the primary demand could always be met from the existing water resources infrastructure. This should, in reality, have been expected since the penalty structure imposed on the model gives much higher preference to primary supply than irrigation supply. Shortages in the primary supply would only occur if there was a complete failure in irrigation supply.

The level of assurance of supply for irrigation in 2015 is significantly improved for the most probable scenario due to the increasing return flows. Even assuming onerous limitations on either the Rand Water supply or the assumed level of return flows, the irrigation sector will be no worse off than at present.

Concerning the amount of water to be supplied from Rand Water in the future (the existing system capacity is 126.2 mcm/a), it will be necessary to carry out a further study including an assessment of alternatives to extending the existing systems. Such an assessment would be carried out mainly from an economical view-point and would consider the marginal cost of the Rand Water supply in order to determine the most preferable option from a national perspective. As the existing capacity is in place, there is clearly no justification in curtailing the supply at a level lower than the existing capacity however, in the long term, when planning is begun to consider replacing the infrastructure, the issue should be revisited. At that stage, the study would also take into account trends in the water resources development program of the Vaal River basin.

It is concluded that the availability of water resources for the supply of primary and irrigation water in the Study Area is at a sufficiently high level when the expected return flows from treated effluent of urban users reaches a certain level, and operation of each storage dam is properly managed.

4.5 Water Quality

4.5.1 Groundwater Quality

Groundwater is widely used within the Study Area for primary water supply, particularly in the northern rural areas. The quality is, however, generally poor and in many cases the yield is inadequate. As part of the Study samples were taken to investigate drinking water quality within the Study Area. Of the twelve groundwater samples which were chosen at random, six may be considered to be unfit for human consumption (having high fluoride or faecal contamination, and none fully complied with the domestic water quality guidelines with an average of four parameters failing per borehole. The potential for developing significant groundwater facilities also appears to be low based on the parameters of accessibility and exploitability. For these reasons the technical solutions proposed are generally based on providing a surface water supply other than for those consumers living in rural areas with a particularly low population density who are assumed to be still supplied from groundwater in the target year, 2015.

Quality problems are primarily associated with contamination by nitrates and fluorides and faecal contamination due to inadequate sanitation. The origin of the fluoride is geological, however a significant portion of the nitrogen load is generated by human activities. Counter-measures might include a publicity programme and regulatory controls on the use of nitrogen based fertilizers in sensitive catchments. In addition, a long term monitoring programme is required to determine trends in nitrogen concentrations.

To assess the quality and to estimate the yield of groundwater within the Study Area a consolidated database was constructed from available borehole information. This information was linked to a GIS which enabled drawings to be produced showing in general terms Harvest Potential, water quality, depth to groundwater, aquifer vulnerability, potential exploitability for rural water supply and yield. Under the DWAF classification, water quality is described as Class 0 to 4. A map of the Study Area was prepared showing the distribution of each Class. Those communities which currently rely on groundwater of Class 3 and 4 (unacceptable quality for domestic use), will be prioritized to receive a surface water supply by 2002 and those using Class 2 groundwater (safe for short term use only), will be programmed to receive a surface water supply by 2015. If additional boreholes are to be provided as a short or medium term option, they should be located outside the village to reduce the risk of groundwater contamination.

The existing information is incomplete and variable in terms of the information parameters available. There is no national programme or Study Area wide programme for monitoring groundwater quality. Under the provisions of the White Paper on Water Supply and Sanitation, all citizens should be entitled to a safe water supply and it is ultimately the responsibility of DWAF to ensure that this is available. Due to the very large number of boreholes in use, it would be impractical to monitor every hole however it is recommended that a sampling regime be established for those communities which are to remain on groundwater. DWAF could undertake such a programme with support from other stakeholders.

4.5.2 Surface Water Quality

The Study has primarily focused on the water quality prevailing within the Study Area although this is heavily influenced by upstream users. The influence of such areas on water quality during the coming years will continue and development in the upstream parts of the river basins will directly impact on surface water quality within the Study Area. An outline of the existing surface water quality is included in Section 2.1.7 and in Chapter 2 of Supporting Report B. An in-depth study of water quality within the catchments modelled during the water balance study would be a major undertaking and if required, should be the subject of a separate study.

From the water balance study, it is apparent that urban runoff and return flows from the PWV area will increase very significantly up to the target year due to increased water consumption and extension of the sewerage network. As has been explained elsewhere, part of this area comprising southern Johannesburg and Pretoria is located in the upper catchments of the Crocodile and Olifants rivers which flow through the Study Area. Many of the wastewater treatment works serving these urban areas discharge treated effluent into the Crocodile River upstream of Hartbeespoort Dam, the Pienaars River upstream of Roodeplaat Dam and into the Apies River upstream of Leeukraal Dam. These dams provide raw water storage for the main water treatment works in the Study Area at Brits (and indirectly Vaalkop), Wallmannsthal / Temba, and Kudube respectively. While the increase in return flows will increase the yield and reliability of these dams, it will present a challenge in terms of water quality management and water treatment.

A coordinated programme for catchment based management involving DWAF, the relevant water boards (MW and Rand Water), local authorities responsible for operation of water care facilities within the catchment should be established and representatives of the organizations involved should meet on a regular basis. The terms of reference of such a group should be to develop a good understanding of the existing conditions and then develop measures to prevent further deterioration of surface water quality. They should be given the necessary budgetary resources to develop the management tools necessary; this may involve the development of water quality models of the catchments concerned. Such an initiative has already been initiated for the Apies River under the sponsorship of Finnish ODA.

Parameters of particular concern include phosphates, (which control eutrophication); TDS (which will be critical to certain sensitive industries and could have a major impact on the profitability of some mining operations); nitrates (which are of concern due to health considerations as well as being a factor in eutrophication); and bacteriological contamination (which has adverse health implications). These parameters are currently monitored by DWAF for major dams and at key points on rivers however more benefit could be gained by using this data in the context of a basin management committee.

4.5.3 Recommendations Concerning Treatment Works Management

Except for the treatment works operated by MW, Brits TLC and Rustenburg TLC, the level of routine sampling and analysis carried out is poor. Little routine monitoring other than for absolutely the most basic parameters is carried out on site.

Daily sampling should be carried out on site and include easily measurable but important parameters such as:

(1) colour
(2) taste
(3) odour
(4) pH
(5) turbidity
(6) chlorine residual

In addition, site specific parameters should also be selected. These might include for example sampling for the metal ion used in the coagulant at a particular works to check treatment performance, ammonia to check for pollution (especially in the case of a river source where quality changes are more significant) and other parameters known to be problematic at a particular location. Where necessary, emergency plans should be prepared for dealing with events which may lead to interruptions of supply or possible harmful health effects; trigger points should be established so that operators know when to advise their superior of operational difficulties.

It is not sufficient to sample and analyse treated water quality. Proper management systems should be established to ensure that necessary adjustment and optimization of the treatment process takes place according to the information obtained from the analysis. The cause of failure to meet water quality guidelines should be established and a strategy for addressing such failures prepared. Where responsibility for the water supply infrastructure is split between Second and Third Tier organizations, a coordinated approach is required to ensure that water reaches the consumer with an adequate residual chlorine level.

Ideally an independent third party should play a monitoring and auditing role in the interests of protecting public health.

Samples taken to investigate the quality of treated water within the Study Area found the quality to be safe; in most cases either conforming with or only marginally exceeding the domestic water quality guidelines. Further water quality data collected for the water treatment works in the Study Area is summarized in the Data Book.

Table 4-1 : Zoning of Study Area

SUPPLY ZONE	SUPPLY AREA	SUPPLY BLOCK
WESTERN	1.Vaalkop North	1. Thabazimbi 2. Mokgalwaneng 3. Sefikile 4. Ramokokstad 5. Saulspoort 6. Mogwase/Sun City
	2. Vaalkop South	7. Bethanie 8. Vaalkop Southern/Bospoort
	3. Barnardsvlei	9. Barnardsvlei Western 10. Barnardsvlei Eastern
	4. Koster	11. Koster 12. Swartruggens
CENTRAL	1. Brits	1. Brits 2. Hartbeespoort
	2. Klipvoor	3. Kipvoor West 4. Klipvoor East 5. Moretele North
	3. Rand Water	6. Rand Water
	4. Temba	7. Kudube North 8. Kudube South 9. Wallmannsthal 10. Warmbaths/Nylstroom
EASTERN	1. Weltevreden	1. Bloedfontein 2. Kameelrivier 3. Mapoch 4. Walkraal
	2. Bronkhorstspruit	5. Bronkhorstspruit 6. Cullinan

Table 4-2 : Summary of Projected Population

SUPPLY ZONE	SUPPLY AREA	SUPPLY BLOCK	POPULATION																	
			1995						2002						2015					
			UH	UL	RH	RM	RL	TOTAL	UH	UL	RH	RM	RL	TOTAL	UH	UL	RH	RM	RL	TOTAL
WESTERN	VAALKOP NORTH	THABAZIMBI	10,355	0	0	2,923	37,523	50,801	12,407	0	0	2,075	40,230	54,712	14,482	0	0	2,685	45,785	62,952
		MOKGALWANENG	0	0	0	0	3,969	3,969	0	0	0	0	3,969	3,969	0	0	0	0	3,969	3,969
		SEFIKILE	2,399	0	0	3,061	10,923	16,383	2,911	0	0	7,155	7,713	17,779	4,168	0	0	9,234	7,713	21,115
		RAMOKOKSTAD	0	0	0	0	9,770	9,770	0	0	0	0	10,475	10,475	0	0	0	0	11,920	11,920
		SAULSPOORT	0	0	0	12,550	53,350	65,900	0	0	0	45,565	27,132	72,697	0	0	0	59,812	28,954	88,766
		MOGWASE/SUN CITY	0	649	0	20,952	21,382	42,983	0	649	0	50,416	0	51,065	0	649	0	69,911	0	70,560
		SUB-TOTAL	12,754	649	0	39,486	136,917	189,806	15,318	649	0	105,211	89,519	210,697	18,650	649	0	141,642	98,341	259,282
	VAALKOP SOUTH	BETHANIE	0	0	22,205	0	15,238	37,443	0	0	26,215	17,989	0	44,204	0	0	35,682	24,488	0	60,170
		VAALKOP SOUTHERN/BO	21,629	39,409	87,970	0	0	149,008	27,518	108,809	49,431	0	0	185,758	37,456	157,377	50,246	0	0	245,079
		SUB-TOTAL	21,629	39,409	110,175	0	15,238	186,451	27,518	108,809	75,646	17,989	0	229,962	37,456	157,377	85,928	24,488	0	305,249
	BARNARDSVLEI	BARNARDSVLEI WESTER	36,828	0	77,455	2,191	97,948	214,422	39,485	0	104,012	105,530	0	249,027	44,937	0	171,076	121,356	0	337,369
		BARNARDSVLEI EASTER	0	10,463	14,157	0	12,000	36,620	0	13,222	16,714	15,791	0	45,727	0	20,421	22,750	26,293	0	69,464
		SUB-TOTAL	36,828	10,463	91,612	2,191	109,948	251,042	39,485	13,222	120,726	121,321	0	294,754	44,937	20,421	193,826	147,649	0	406,833
	KOSTER	KOSTER	1,738	0	9,581	0	22,905	34,224	1,738	0	11,006	0	24,557	37,301	1,738	0	14,237	0	27,948	43,923
		SWARTRUGGENS	1,006	0	3,080	0	10,241	14,327	1,006	0	3,538	0	10,980	15,524	1,006	0	4,577	0	12,496	18,079
		SUB-TOTAL	2,744	0	12,661	0	33,146	48,551	2,744	0	14,544	0	35,537	52,825	2,744	0	18,814	0	40,444	62,002
	TOTAL		73,955	50,521	214,448	41,677	295,249	675,850	85,065	122,680	210,916	244,521	125,056	788,238	103,787	178,447	298,568	313,779	138,785	1,033,366
CENTRAL	BRITS	BRITS	46,463	0	0	0	96,399	142,862	57,443	0	0	105,444	3,175	166,062	85,390	0	0	135,827	3,710	224,927
		HARTBEESPOORT	7,450	0	0	0	0	7,450	8,796	0	0	0	0	8,796	11,972	0	0	0	0	11,972
		SUB-TOTAL	53,913	0	0	0	96,399	150,312	66,239	0	0	105,444	3,175	174,858	97,362	0	0	135,827	3,710	236,899
	KLIPVOOR	KLIPVOOR WEST	0	499	0	0	9,198	9,697	0	499	0	0	9,198	9,697	0	499	0	0	9,198	9,697
		KLIPVOOR EAST	0	0	0	0	28,789	28,789	0	0	0	293	28,496	28,789	0	0	0	293	28,496	28,789
		MORETELE NORTH	0	0	0	0	15,830	15,830	0	0	0	0	15,830	15,830	0	0	0	0	15,830	15,830
		SUB-TOTAL	0	499	0	0	53,817	54,316	0	499	0	293	53,524	54,316	0	499	0	293	53,524	54,316
	RAND WATER	RAND WATER	19,481	164	508,428	38,253	370,994	937,320	23,157	164	706,418	498,131	0	1,227,870	31,922	164	1,242,161	794,341	0	2,068,588
		SUB-TOTAL	19,481	164	508,428	38,253	370,994	937,320	23,157	164	706,418	498,131	0	1,227,870	31,922	164	1,242,161	794,341	0	2,068,588
	TEMBA	KUDUBE NORTH	0	60,377	0	139,370	887	200,634	0	77,194	0	165,389	0	242,583	0	119,127	0	229,523	0	348,650
		KUDUBE SOUTH	0	137	0	208,752	2,461	211,350	0	137	0	259,060	2,461	261,658	0	137	0	388,279	2,461	390,877
		WALLMANNSTHAL	0	6,000	0	0	0	6,000	0	7,084	0	0	0	7,084	0	9,642	0	0	0	9,642
		WARMBAD/NYLSTROOM	12,287	148	0	33,934	61,995	108,364	12,287	148	0	37,662	66,467	116,564	12,287	148	0	45,705	75,646	133,786
		SUB-TOTAL	12,287	66,662	0	382,056	65,343	526,348	12,287	84,563	0	462,111	68,928	627,889	12,287	129,054	0	663,507	78,107	882,955
	TOTAL		85,681	67,325	508,428	420,309	586,553	1,668,296	101,683	85,226	706,418	1,965,979	125,627	2,084,933	141,571	129,717	1,242,161	1,593,968	135,341	3,242,758
EASTERN	WELTEVREDEN	BLOEDFONTEIN	0	0	0	0	159,120	159,120	0	0	0	159,328	0	159,328	0	0	0	159,791	0	159,791
		KAMEELRIVIER	0	0	0	0	41,381	41,381	0	0	0	43,416	0	43,416	0	0	0	47,941	0	47,941
		MAPOCH	0	0	0	0	16,254	16,254	0	0	0	18,416	0	18,416	0	0	0	23,223	0	23,223
		WALKRAAL	0	0	0	122,547	179,825	302,372	0	0	0	331,896	863	332,759	0	0	0	400,321	0	400,321
		SUB-TOTAL	0	0	0	122,547	396,580	519,127	0	0	0	553,056	863	553,919	0	0	0	631,276	0	631,276
	BRONKHORSTSPRUIT	BRONKHORSTSPRUIT	12,000	0	0	189,061	809	201,870	13,784	0	0	216,723	0	230,507	17,831	0	0	277,746	0	295,577
		CULLINAN	9,085	0	0	16,500	24,187	49,772	10,725	0	0	21,713	25,931	58,369	14,600	0	0	36,154	29,512	80,266
		SUB-TOTAL	21,085	0	0	205,561	24,996	251,642	24,509	0	0	238,436	25,931	288,876	32,431	0	0	313,900	29,512	375,843
	TOTAL		21,085	0	0	328,108	421,576	770,769	24,509	0	0	791,492	26,794	842,795	32,431	0	0	945,176	29,512	1,007,119
GRAND-TOTAL			180,721	117,846	722,876	790,094	1,303,378	3,114,915	211,257	207,906	917,334	2,101,992	277,477	3,715,966	277,289	308,164	1,540,729	2,852,923	303,638	5,283,243

Note: 1) UH: Urban High, UL: Urban Low, RH: Rural High, RM: Rural Medium, RL: Rural Low

Table 4-3 : Projected Mixes of Levels of Service

Classification of Community	Level of Service	% of House Connections (Water Consumption per Capita)	% of Yard Taps (Water Consumption per Capita)	% of Street Taps (Water Consumption per Capita)
Urban	High	100 (Actual)	0	0
	Low	75 (230 lcd)	15 (70 lcd)	10 (30 lcd)
Rural	High	75 (120 lcd)	15 (70 lcd)	10 (30 lcd)
	Medium	20 (120 lcd)	60 (70lcd)	20 (30 lcd)
	Low	5 (120 lcd)	15 (70 lcd)	80 (30 lcd)

Table 4-4 : Summary of Projected Primary Water Demand

SUPPLY ZONE	SUPPLY AREA	SUPPLY BLOCK	PRIMARY WATER DEMAND (mcm/a)																	
			1995						2002						2015					
			DOM	IND	COM	INS	MIN	TOTAL	DOM	IND	COM	INS	MIN	TOTAL	DOM	IND	COM	INS	MIN	TOTAL
WESTERN	VAALKOP NORTH	THABAZIMBI	2.912	0.345	0.252	0.168	18.412	22.089	3.258	0.370	0.271	0.180	20.322	24.401	3.936	0.421	0.308	0.205	23.871	28.741
		MOKGALWANENG	0.071	0.225	0	0	0	0.296	0.070	0.338	0	0	0	0.408	0.067	0.548	0	0	0	0.615
		SEFIKILE	0.534	0	0	0	5.074	5.608	0.646	0	0	0	5.633	6.279	0.812	0	0	0	6.670	7.482
		RAMOKOKSTAD	0.174	0	0	0	0	0.174	0.183	0	0	0	0	0.183	0.201	0	0	0	0	0.201
		SAULSPOORT	1.341	0	0	0	2.497	3.838	1.892	0	0	0	2.592	4.484	2.300	0	0	0	2.592	4.892
		MOGWASE/SUN CITY	1.092	3.719	2.920	0	0	7.731	1.618	3.987	3.263	0	0	8.868	2.163	4.537	4.011	0	0	10.711
		SUB-TOTAL	6.124	4.289	3.172	0.168	25.983	39.736	7.667	4.695	3.534	0.180	28.547	44.623	9.479	5.506	4.319	0.205	33.133	52.642
	VAALKOP SOUTH	BETHANIE	1.277	0	0	0	0	1.277	1.729	0	0	0	0	1.729	2.290	0	0	0	0	2.290
		VAALKOP SOUTHERN/BOSPO	10.107	0.436	0.327	0.218	2.896	13.984	14.406	1.023	0.410	0.273	2.896	19.008	18.818	1.818	0.542	0.362	2.896	24.436
		SUB-TOTAL	11.384	0.436	0.327	0.218	2.896	15.261	16.135	1.023	0.410	0.273	2.896	20.737	21.108	1.818	0.542	0.362	2.896	26.726
	BARNARDSVLEI	BARNARDSVLEI WESTERN	9.1	1.676	0.557	0.371	8.314	20.018	11.92	2.099	0.588	0.392	9.063	24.062	15.511	3.347	0.651	0.434	9.063	29.006
		BARNARDSVLEI EASTERN	1.706	0	0	0	8.305	10.013	2.298	0	0	0	8.997	11.295	3.378	0	0	0	9.775	13.153
		SUB-TOTAL	10.806	1.676	0.557	0.371	16.619	30.029	14.218	2.099	0.588	0.392	18.06	35.357	18.889	3.347	0.651	0.434	18.838	42.159
	KOSTER	KOSTER	1.019	0	0.04	0.02	0	1.079	1.095	0	0.04	0.02	0	1.155	1.267	0	0.04	0.02	0	1.327
		SWARTRUGGENS	0.421	0	0.03	0.01	0	0.461	0.448	0	0.02	0.01	0	0.478	0.506	0	0.02	0.01	0	0.536
		SUB-TOTAL	1.44	0	0.07	0.03	0	1.54	1.543	0	0.06	0.03	0	1.633	1.773	0	0.06	0.03	0	1.863
	TOTAL	TOTAL	29.754	6.401	4.126	0.787	45.498	86.566	39.563	7.817	4.592	0.875	49.503	102.35	51.249	10.671	5.572	1.031	54.867	123.390
CENTRAL	BRITS	BRITS	8.26	1.286	0.436	0.291	0	10.273	11.416	1.636	0.696	0.464	0	14.212	16.12	2.558	1.141	0.867	0	20.686
		HARTBEESPOORT	3.263	0	0	0	0	3.263	3.853	0	0	0	0	3.853	5.244	0	0	0	0	5.244
		SUB-TOTAL	11.523	1.286	0.436	0.291	0	13.536	15.269	1.636	0.696	0.464	0	18.065	21.364	2.558	1.141	0.867	0	25.93
	KLIPVOOR	KLIPVOOR WEST	0.202	0	0	0	0	0.202	0.201	0	0	0	0	0.201	0.196	0	0	0	0	0.196
		KLIPVOOR EAST	0.512	0	0	0	0	0.512	0.509	0	0	0	0	0.509	0.494	0	0	0	0	0.494
		MORETELE NORTH	0.281	0	0	0	0	0.281	0.276	0	0	0	0	0.276	0.268	0	0	0	0	0.268
		SUB-TOTAL	0.995	0	0	0	0	0.995	0.986	0	0	0	0	0.986	0.958	0	0	0	0	0.958
	RAND WATER	RAND WATER	34.277	9.92	0	0	0	44.197	49.587	12.036	0	0	0	61.623	81.479	17.28	0	0	0	98.759
		SUB-TOTAL	34.277	9.92	0	0	0	44.197	49.587	12.036	0	0	0	61.623	81.479	17.28	0	0	0	98.759
	TEMBA	KUDUBE NORTH	9.675	3.701	0.5	0	0	13.876	11.846	4.709	0.5	0	0	17.055	17.259	5.991	0.5	0	0	23.75
		KUDUBE SOUTH	6.642	0	0	0	0	6.642	8.106	0	0	0	0	8.106	11.79	0	0	0	0	11.79
		WALLMANNSTHAL	2.464	0	0	0	0	2.463	2.909	0	0	0	0	2.909	3.434	0	0	0	0	3.434
		WARMBAD/NYLSTROOM	4.231	0.41	1.046	0.205	0	5.892	4.365	0.433	1.12	0.202	0	6.12	4.644	0.447	1.318	0.196	0	6.605
		SUB-TOTAL	23.012	4.111	1.546	0.205	0	28.874	27.226	5.142	1.62	0.202	0	34.19	37.127	6.438	1.818	0.196	0	45.579
	TOTAL	TOTAL	69.807	15.317	1.982	0.496	0	87.602	93.068	18.814	2.316	0.666	0	114.864	140.928	26.276	2.959	1.063	0	171.226
EASTERN	WELTEVREDEN	BLOEDFONTEIN	2.860	0	0	0	0	2.860	3.839	0	0	0	0	3.839	4.755	0	0	0	0	4.755
		KAMEELRIVIER	0.735	0	0	0	0	0.735	1.350	0	0	0	0	1.35	1.45	0	0	0	0	1.45
		MAPOCH	0.288	0	0	0	0	0.288	0.573	0	0	0	0	0.573	0.701	0	0	0	0	0.701
		WALKRAAL	6.412	0	0	0	0	6.412	10.331	0	0	0	0	10.331	12.101	0	0	0	0	12.101
		SUB-TOTAL	10.295	0	0	0	0	10.295	16.093	0	0	0	0	16.093	19.007	0	0	0	0	19.007
	BRONKHORSTSPRUIT	BRONKHORSTSPRUIT	6.693	3.614	0.192	0.128	0	10.627	7.577	3.66	0.226	0.151	0	11.614	9.738	3.748	0.293	0.195	0	13.974
		CULLINAN	1.769	0.089	0.107	0.071	1.11	3.146	2.092	0.105	0.126	0.083	1.11	3.516	2.897	0.143	0.171	0.114	1.11	4.435
		SUB-TOTAL	8.462	3.703	0.299	0.199	1.11	13.773	9.669	3.765	0.352	0.234	1.11	15.13	12.635	3.891	0.464	0.309	1.11	18.409
	TOTAL	TOTAL	18.757	3.703	0.299	0.199	1.11	24.068	25.762	3.765	0.352	0.234	1.11	31.223	31.642	3.891	0.464	0.309	1.11	37.416
GRAND-TOTAL		GRAND-TOTAL	118.318	25.421	6.407	1.482	46.608	198.236	158.393	30.396	7.26	1.775	50.613	248.437	223.819	40.838	8.995	2.403	55.977	332.032

Notes : 1) Primary water demand shown in the table includes system leakage losses (1995: 20 %, 2002: 18.25 %, 2015: 15 %),but excludes losses at the purification plant and from the raw water source to the purification plant.

2) DOM: Domestic, IND: Industrial, COM: Commercial, INS: Institutional, MIN: Mining

Table 4-5 : Summary of Water Usage in Irrigation

Sub-Catchment		Area Irrigated (ha)				Water Demand (mcm/a)				Water Resouces (mcm/a)	
		GWS	IB	P	Total	GWS	IB	P	Total	Reser-voir	Run of river
Upper Crocodile	A21	20,893	998	9,058	30,949	136.6	6.9	58.0	201.5	136.6	64.9
Elands River	A22	2,468	1,628	2,710	6,806	14.0	16.0	15.0	45.0	28.3	16.7
Pienaars River	A23	7,445	1,197	5,197	13,839	59.3	11.0	52.0	122.3	2.4	39.9
Lower Crocodile	A24	3,840	-	2,859	6,699	31.0	-	32.0	63.0	0.0	63.0
Sub-Total		34,646	3,823	19,824	58,293	240.9	33.9	157.0	431.8	247.3	184.5
Olifants Trib.	B20, B31	-	340	740	1,080	-	2.6	7.2	9.8	0.7	9.1
Sub-Total		0	340	740	1,080	0	2.6	7.2	9.8	0.7	9.1
Total		34,646	4,163	20,564	59,373	240.9	36.5	164.2	441.6	248.0	193.6

Notes: GWS Government Water Schemes
IB Irrigation Board Schemes
P Private Irrigation Schemes

Table 4-6 : Acceptable Return Periods and Allowable Shortages (%)

User Group	Allowable Shortage (%) in Acceptable Return Period		
	1:20	1:100	1:200
Urban*	20	30	50
Mining**	0	30	70
Agriculture	50	40	10

Note) * The urban user group includes domestic and industrial users.
** The mining group include mining and power generation.

Table 4-7 : Water Demand in the Target Year 2015

User Group	1995		2015	
	Water Demand (mcm/a)	Share (%)	Water Demand (mcm/a)	Share (%)
Urban *	158.5	24.1	282.3	35.5
Mining *	58.1	8.8	71.7	9.0
Agriculture	441.6	67.1	441.6	55.5
Total	658.2	100.0	795.6	100.0

Note) * These figures indicate net water demand excluding the allowances of 5% for losses at the treatment works and an additional percentage (determined on a case by case basis) for losses between the raw water source and the treatment works.

Table 4-8 : Probable Drought River Runoff in the Study Area

River System	Point (Dam)	Catchment (km^2)	Naturalised River Runoff (mcm/a)				
			MAR	1:10	1:20	1:50	1:100
1 Olifants River	(1) Upstream of Bronkhorstspruit	1,260	47.4	14.2	11.9	10.4	9.5
	(2) Between (1) and Premier Dam	1,604	55.1	16.5	13.8	12.1	11.0
	(3) Upstream of Mkombo Dam	3,723	54.8	10.4	5.1	4.1	3.5
Total		6,587	157.3	41.1	30.8	26.6	24.0
2 Crocodile River Pienaars River	(1) Upstream Bon Accord Dam	390	25.0	12.3	11.2	10.2	7.5
	(2) Upstream Roodeplaat Dam	682	33.0	13.2	11.6	10.6	9.9
	(3) Between (1), (2) and Klipvoor Dam	6,577	80.7	12.8	9.7	8.1	7.2
Sub-Total		7,649	138.7	38.3	32.5	28.9	24.6
Upper Crocodile River	(4) Upstream of Hartbeespoort Dam	4,107	177.3	73.8	59.5	52.1	46.2
	(5) Between (4) and Roodekopies Dam	2,016	11.6	1.9	1.4	1.1	1.0
Sub-Total		6,123	188.9	75.7	60.9	53.2	47.2
Elands River	(6) Upstream of Bospoort Dam	1,078	24.4	3.5	2.8	2.4	2.1
	(7) Upstream of Koster Dam	284	6.7	0.9	0.7	0.6	0.5
	(8) Between (6), (7) and Vaalkop Dam	4,859	81.8	12.6	9.7	8.1	7.2
Sub-Total		6,221	112.9	17.0	13.2	11.1	9.8
Lower Crocodile River	(9) Bierspruit confluence	7,015	102.7	7.8	5.6	4.4	4.0
Sub-Total		7,015	102.7	7.8	5.6	4.4	4.0
Total		20,789	543.2	138.8	112.2	97.6	85.6

Table 4-9 : Estimated Return Flows and Urban Runoff Case 1 (1995 base)

River Section	Return Flow (mcm/a)	Urban Runoff (mcm/a)	Total (mcm/a)	Naturalised RR* (mcm/a)
Pienaars to Klipvoor	89.5	15.7	105.2	138.7
Upper Crocodile	120.0	29.3	149.3	177.3
Hartbeespoort to Roodekoppies	1.7	0.0	1.7	72.3
Elands to Vaalkop	11.0	0.0	11.0	112.9
Total	222.2	45.0	267.2	501.2

Table 4-10 : Projected Return Flow and Urban Runoff in the Crocodile River Case 2 and Case 3 - Alternatives 1 and 3 (2015)

River Section	Return Flow (mcm/a)	Urban Runoff (mcm/a)	Total (mcm/a)	Naturalised RR* (mcm/a)
Pienaars to Klipvoor	178.9	15.7	194.6	138.7
Upper Crocodile	207.6	29.3	236.9	177.3
Hartbeespoort to Roodekoppies	2.4	0.0	2.4	72.3
Elands to Vaalkop	22.0	0.0	22.0	112.9
Total	410.9	45.0	455.9	501.2

Table 4-11 : Assumed Return Flows and Urban Runoff Case 3 - Alternative 2 (2015)

River Section	Return Flow (mcm/a)	Urban Runoff (mcm/a)	Total (mcm/a)	Naturalised RR* (mcm/a)
Pienaars to Klipvoor	141.1	15.7	156.8	138.7
Upper Crocodile	166.3	29.3	195.6	177.3
Hartbeespoort to Roodekoppies	1.2	0.0	1.2	72.3
Elands to Vaalkop	11.0	0.0	11.0	112.9
Total	319.6	45.0	364.6	501.2

* Note: Naturalised river runoff indicates mean annual runoff (MAR)

Table 4-12 : Present and Projected Groundwater Utilization

Year	Eastern (mcm/a)	Central (mcm/a)	Western(mcm/a)	Total (mcm/a)
A. Primary Use				
1995				
- Class 0 / 1	2.2	3.1	3.2	8.5
- Class 2	0.1	0.1	0.4	0.6
- Class 3 / 4	0.0	0.4	0.2	0.6
2002				
- Class 0 / 1	2.2	3.1	2.5	7.8
- Class 2	0.2	0.1	0.6	0.9
- Class 3 / 4	0.0	0.0	0.0	0.0
2015				
- Class 0 / 1	1.1	1.3	2.6	5.0
- Class 2	0.0	0.0	0.0	0.0
- Class 3 / 4	0.0	0.0	0.0	0.0
B. Mining use	0.0	0.0	12.4	12.4

Note) The water requirements indicated in the water balance simulation are the net figures after deducting the above amount of groundwater available from the estimated total primary water requirement.

Table 4-13 : Required Surface Water Amount for Projected Primary Water

Area/Block	1995			2002			2015		
	Total (mcm)	Ground-water (mcm)	Surface Water (mcm)	Total (mcm)	Ground -water (mcm)	Surface Water (mcm)	Total (mcm)	Ground-water (mcm)	Surface Water (mcm)
Eastern	32.884	2.320	30.564	41.069	2.369	38.700	50.503	1.098	49.405
Central	98.891	4.264	94.627	127.800	3.307	124.493	188.075	1.290	186.785
Western	94.733	13.850	80.883	108.951	13.980	94.971	121.330	13.100	108.230
Total	226.507	20.434	206.073	277.821	19.656	258.165	359.908	15.488	344.420

Table 4-14 : Water Availability from Rand Water

Case	Alternative	Year	Central Zone	Western Zone	Total
1	-	1995	42.1	39.3	81.4 *
2	-	2015	86.9	39.3	126.2 **
3	1	2015	42.1	39.3	81.4
	2	2015	86.9	39.3	126.2
	3	2015	42.1	39.3	81.4

Note) * Current supply level on Annual Average Daily Demand (AADD) basis
** Maximum capacity of existing systems on AADD basis.

Table 4-15 : Summary of Water Balance of Case 1 (1995 base)

Water Resource	Primary Water (mcm/a)		Irrigation Water (mcm/a)			
	Requirement	Supply	Requirement		Supply	
	Storage Dam	Storage Dam	Storage Dam	River	Storage Dam	River
1. Local Water						
- Upper Crocodile	15.0	15.0	136.6	64.9	131.6	45.0
- Pienaars	32.5	32.5	82.4	39.9	73.9	30.1
- Elands	33.4	33.0	28.3	16.7	18.8	5.3
- Lower Crocodile	0.0	0.0	0.0	63.0	0.0	45.4
- Bronkhorstspruit	19.2	19.2	0.7	0.0	0.6	0.0
- Elands (Olifants)	1.7 + 9.5	1.7 + 9.5*	0.0	9.1	0.0	7.3
Sub-total	111.3	110.9	248.0	193.6	224.9	133.1
2. Rand Water	81.4	81.4	-	-	-	-
Grand Total	192.7	192.3	248.0	193.6	224.9	133.1

Note) * Imported water from Loskop dam

Table 4-16 : Summary of Water Balance of Case 2 (Base Plan - 2015 base)

Water Resource	Primary Water (mcm/a)		Irrigation Water (mcm/a)			
	Requirement	Supply	Requirement		Supply	
	Storage Dam	Storage Dam	Storage Dam	River	Storage Dam	River
1. Local Water						
- Upper Crocodile	28.7	28.7	136.6	64.9	136.6	53.0
- Pienaars	49.1+20.1	49.1+20.1 *	82.4	39.9	78.5	33.0
- Elands	67.742.1+22.4	67.742.1+22.4 **	28.3	16.7	18.8	5.6
- Lower Crocodile	0.0	0.0	0.0	63.0	0.0	47.1
- Bronkhorstspruit	22.5+4.9	22.5+4.9***	0.7	0.0	0.6	0.0
- Elands (Olifants)	12.5+9.5	12.5+9.5****	0.0	9.1	0.0	7.3
Sub-total	216.9	216.2	248.0	193.6	234.5	146.0
2. Rand Water	126.2	126.2	-	-	-	-
Grand Total	343.1	342.4	248.0	193.6	234.5	146.0

Note) * Transfered water from Rand Water to the Rand Water Supply Area in Central Zone
** Transfered water from Rand Water to the Barnardsvlei Suply Area in Western Zone
*** Imported water from Grootdraai dam
**** Imported water from Loskop dam

Table 4-17 : Summary of Water Balance for Case 3 - Alternative 1 (2015 base)

Water Resource	Primary Water (mcm/a)		Irrigation Water (mcm/a)			
	Requirement	Supply	Requirement		Supply	
	Storage Dam	Storage Dam	Storage Dam	River	Storage Dam	River
1. Local Water						
- Upper Crocodile	28.7+32.4	28.7+32.4*	136.6	64.9	121.6	53.0
- Pienaars	49.1+32.5	49.1+32.5*	82.4	39.9	82.0	33.0
- Elands	42.1+12.7+9.7	42.1+12.7+9.7**	28.3	16.7	18.8	5.3
- Lower Crocodile	0.0	0.0	0.0	63.0	0.0	48.4
- Bronkhorstspruit	22.5+4.9	22.5+4.9***	0.7	0.0	0.6	7.3
- Elands (Olifants)	12.5+9.5	12.5+9.5***	0.7	9.1	0.6	7.3
Sub-total	261.7	261.0	248.0	193.6	223.0	147.0
2. Rand Water	81.4	81.4	-	-	-	-
Grand Total	343.1	342.4	248.0	193.6	223.0	147.0

Table 4-18 : Summary of Water Balance for Case 3 - Alternative 3 (2015 base)

Water Resource	Primary Water (mcm/a)		Irrigation Water (mcm/a)			
	Requirement	Supply	Requirement		Supply	
	Storage Dam	Storage Dam	Storage Dam	River	Storage Dam	River
1. Local Water						
- Upper Crocodile	28.7+16.2	28.7+16.2*	136.6	64.9	136.6	53.0
- Pienaars	49.1+48.7	49.1+48.7*	82.4	39.9	77.3	33.0
- Elands	42.1+12.7+9.7	42.1+12.7+9.7**	28.3	16.7	18.8	5.3
- Lower Crocodile	0.0	0.0	0.0	63.0	0.0	48.4
- Bronkhorstspruit	22.5+4.9	22.5+4.9***	0.7	0.0	0.6	0.0
- Elands (Olifants)	12.5+9.5	12.5+9.5****	0.0	9.1	.0	7.3
Sub-total	261.7	261.0	248.0	193.6	233.3	147.0
2. Rand Water	81.4	81.4	-	-	-	-
Grand Total	343.1	342.4	248.0	193.6	233.3	147.0

Note) * Transfered water from Rand Water to the Rand Water Supply Area in Central Zone
** Transfered water from Rand Water to the Barnardsvlei Supply Area in Western Zone
*** Imported water from Grootdraai dam.
**** Imported water from Loskop dam

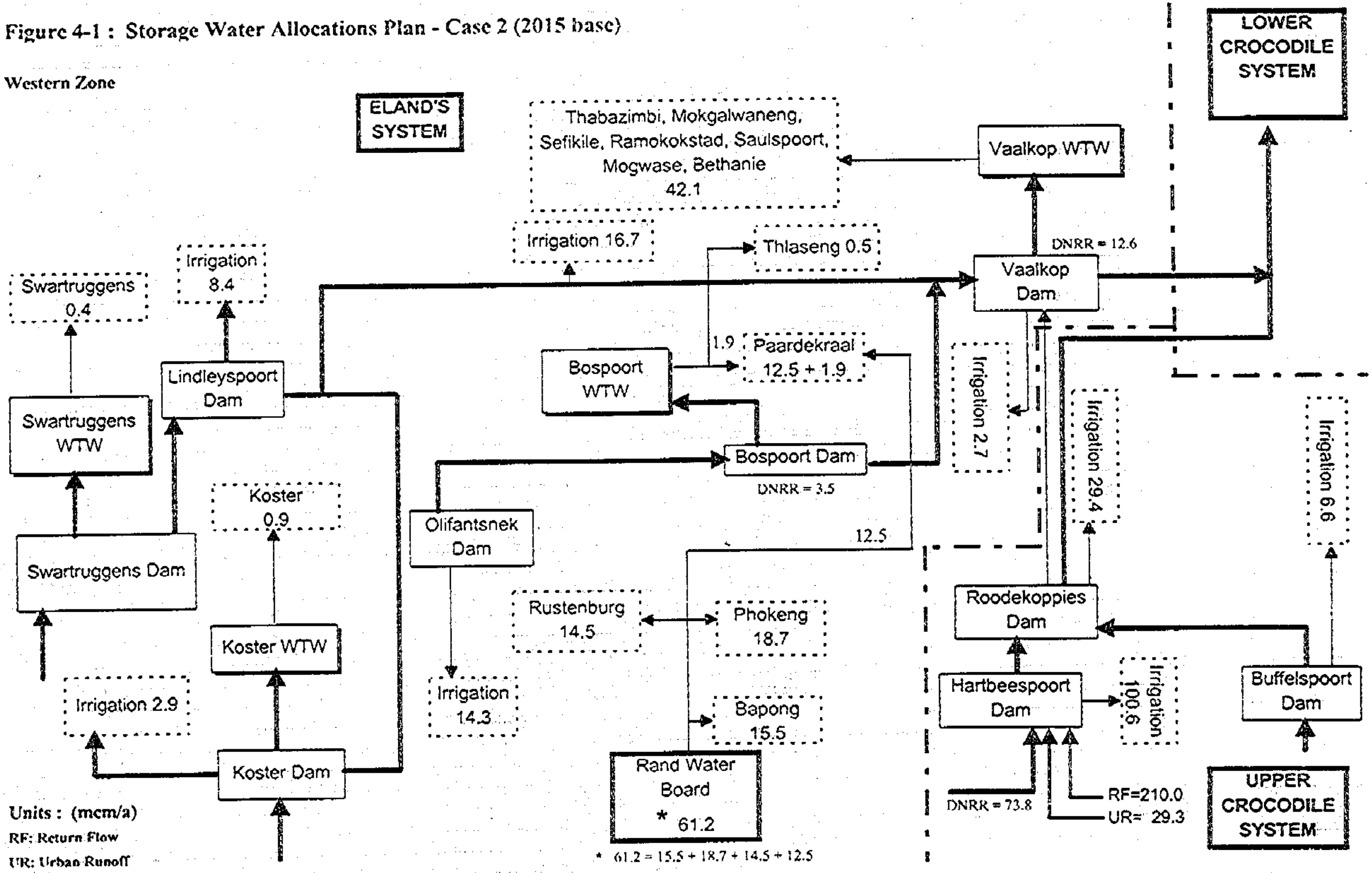
Table 4-19 : Summary of Water Balance for Case 3 - Alternative 2 (2015 base)

Water Resource	Primary Water (mcm/a)		Irrigation Water (mcm/a)			
	Requirement	Supply	Requirement		Supply	
	Storage Dam	Storage Dam	Storage Dam	River	Storage Dam	River
1. Local Water						
- Upper Crocodile	28.7	28.7	136.6	64.9	136.6	53.0
- Pienaars	49.1+20.1	49.1+20.1*	82.4	39.9	75.0	33.0
- Elands	42.1+12.7+9.7	42.1+12.7+9.7**	28.3	16.7	18.8	5.3
- Lower Crocodile	0.0	0.0	0.0	63.0	0.0	46.6
- Bronkhorstspruit	22.5+4.9	22.5+4.9***	0.7	0.0	0.6	0.0
- Elands (Olifants)	12.5+9.5	12.5+9.5****	0.0	9.1	0.6	7.3
Sub-total	216.9	216.2	248.0	193.6	231.6	145.2
2. Rand Water	126.2	126.2	-	-	-	-
Grand Total	343.1	342.4	248.0	193.6	231.6	145.2

Note) * Transfered water from Rand Water to the Rand Water Supply Area in Central Zone
** Transfered water from Rand Water to the Barnardsvlei Suply Area in Western Zone
*** Imported water from Grootdraai dam.
**** Imported water from Loskop dam

Figure 4-1 : Storage Water Allocations Plan - Case 2 (2015 base)

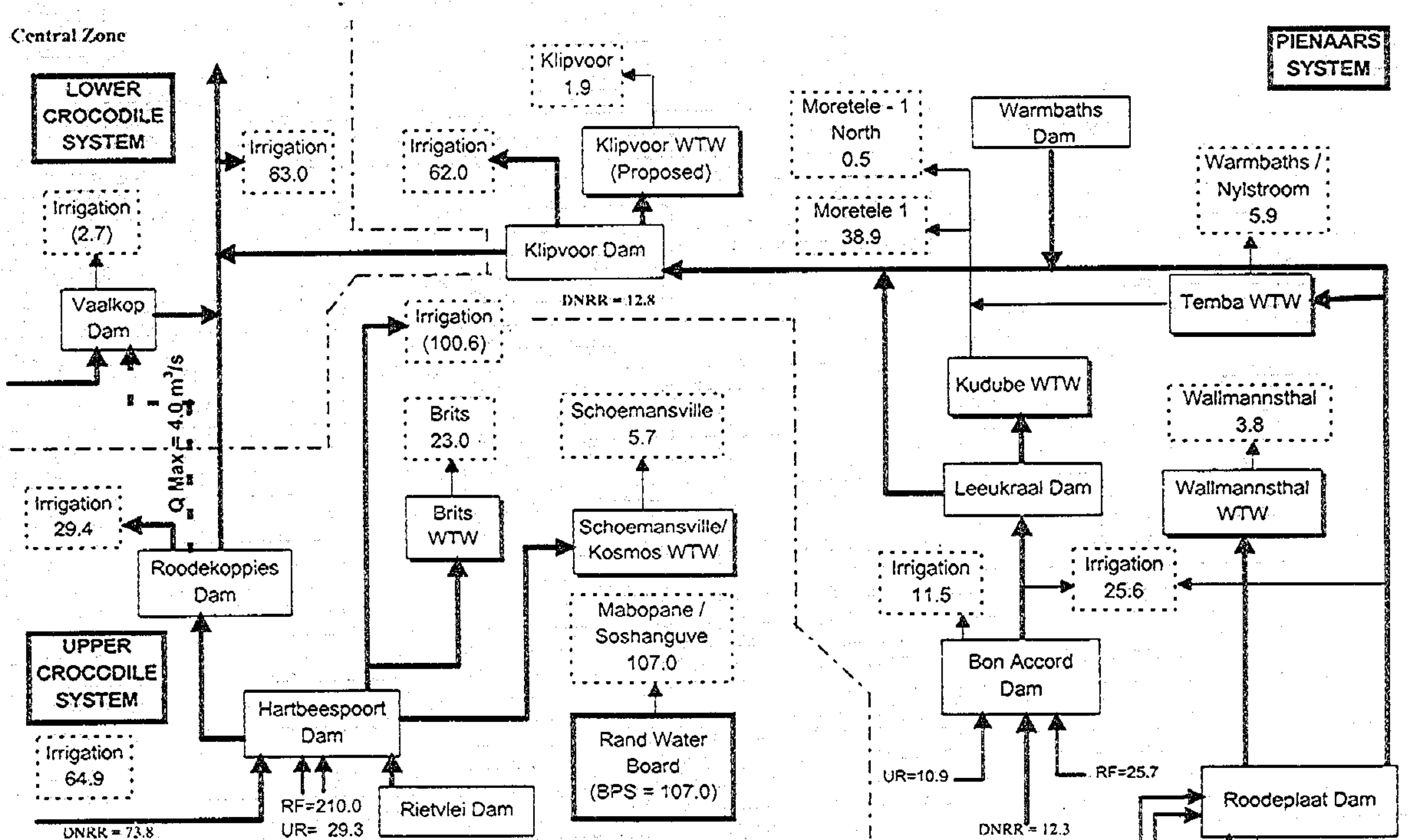
Western Zone



* 61.2 = 15.5 + 18.7 + 14.5 + 12.5

Units : (mcm/a)
RF: Return Flow
UR: Urban Runoff
Note : DNRR indicates Drought Naturalised River Runoff at one in ten year return period.

Figure 4-2 : Storage Water Allocation Plan - Case 2 (2015 base)



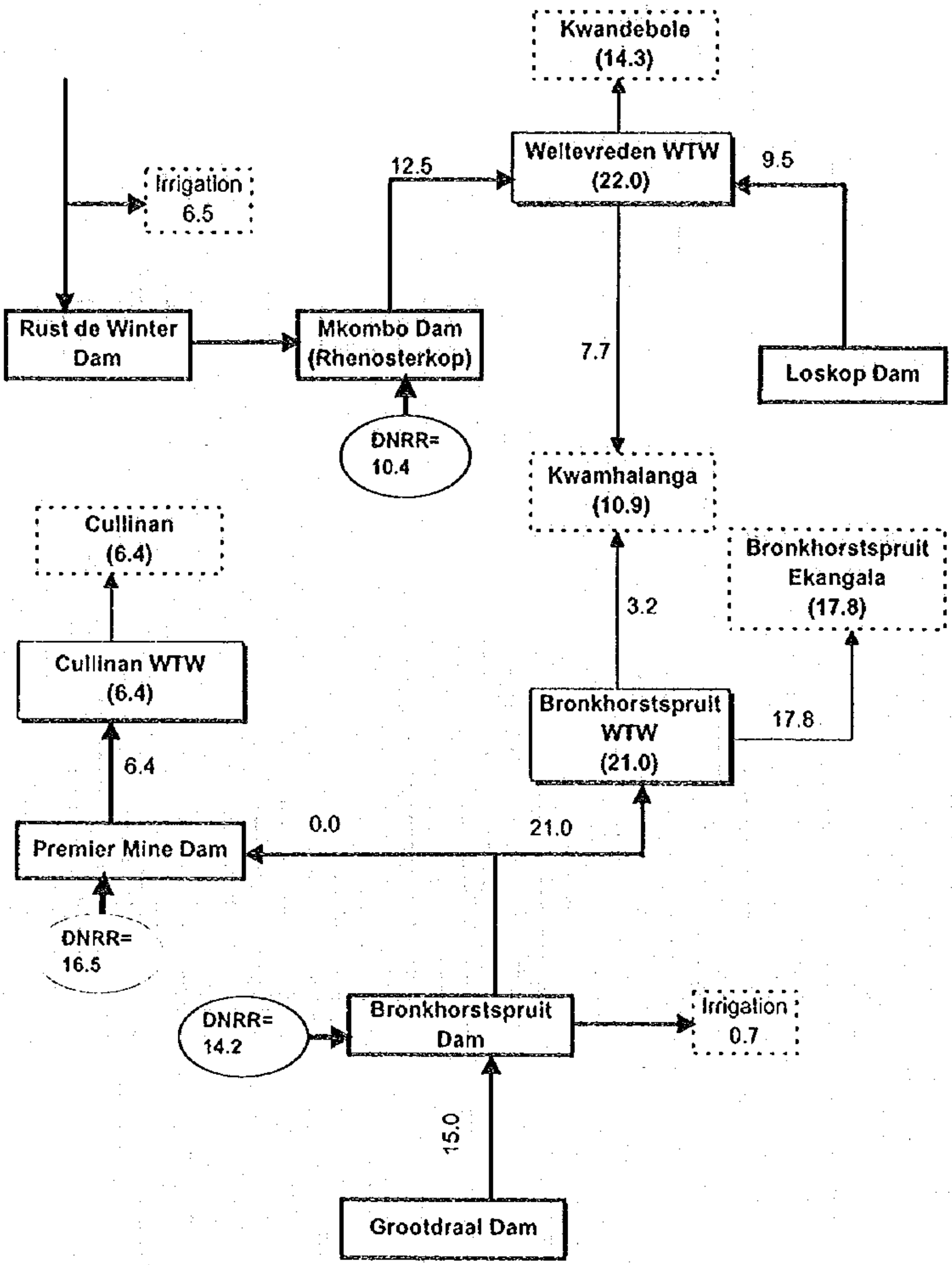
Units : (mcm/a)

Note : DNRR indicates Drought Naturalised River Runoff at one in ten year return period.

Unit :(mcm/a)
RF: Return Flow
UR: Urban Runoff

Figure 4-3 : Storage Water Allocation Plan - Case 2 (2015 base)

Eastern Zone



Units : (mcm/a)
Note : DNRR indicates Drought Naturalised River Runoff at one in ten year return period.

CHAPTER 5 INFRASTRUCTURE DEVELOPMENT PLANNING

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CHAPTER 5 INFRASTRUCTURE DEVELOPMENT PLANNING

5.1 Assumed Design Standards and Cost Curves

Infrastructure development planning can be viewed as the core of the technical component of Phase 1 of the Study. All other technical tasks were either required in preparation for the infrastructure development planning, or resulted from it.

In order to ensure a consistent approach, it was necessary as an initial step to determine design and cost parameters to form the basis for the technical planning and costing. Criteria for process selection, sizing of pipes and structures, information on materials and cost criteria, typical of work undertaken in the past within the Study Area were identified and recorded. The criteria and parameters selected for this purpose are presented in the Data Book.

It is important to note that the design and costing criteria included in the Data Book were prepared to record and to inform interested parties of the standards applied during the preliminary technical planning. The criteria presented are only representative of generally accepted design and costing parameters, and are in no way intended to be interpreted as representing the official technical standards applied by Magalies Water or supported by Magalies Water for application within the Study Area. The assumed design standards do however include many standards that have in the past been applied by Magalies Water, and can possibly therefore serve as a future basis upon which Magalies Water can develop formal design and costing standards and/or guidelines for its extended supply area. During Phase 2 of the Study, applicable design assumptions will be discussed and agreed with MW and other relevant parties for the purpose of the Feasibility Study.

Design standards and cost curves were developed specifically for the following components of the water supply infrastructure.

- storage dams and diversion weirs;
- conveyance canals;
- water treatment works;
- delivery and distribution pipelines;
- pumping stations;
- service reservoirs;
- reticulation; and
- boreholes.

A summary of the standards and cost curves used is provided in Chapter 5 of Supporting Report E and the detailed information is included in Part H of the Data Book.

5.2 General Planning Approach

The planning approach developed for the Study Area was as follows :

(1) The Study Area was grouped into Supply Blocks, Areas and Zones. These units were then assigned to the various existing or potential water sources, in accordance with the results of the water balance study. Where the water balance study indicated more than one possible source, technical options were investigated.

(2) Each Supply Block was represented schematically on supply diagrams that were generated using a spreadsheet. The primary demand that is estimated for each community was transferred to the schematic. Two spreadsheets were generated for each Supply Block, the first representing the status quo situation, and the second the upgrading that will be required in order to meet primary water demands in the year 2015. For Supply Blocks where there is no existing infrastructure, the first spreadsheet was not produced.

(3) For each Supply Block, the capacity of the existing infrastructure was tested against the estimated 2015 primary water demands. Capacity shortfalls were indicated on the first spreadsheet.

(4) Where existing infrastructure does not have sufficient capacity to meet the projected 2015 demands, a possible technical option was formulated and costed (second spread sheet) using the cost curves described in Section 5.1 above. In a number of cases more than one viable technical option was identified. In such cases each of the alternative technical options was planned and costed and then evaluated to determine the most favourable option.

(5) The schematic layouts indicate the flow sequence, size, capacity and cost of proposed new infrastructural components within each Supply Block. Such characteristics are also shown on the first sheet, (but without the associated costs), for existing infrastructural components. Schematics for each Supply Block and Cost Summary Sheets indicating total demand, capacities, pipework lengths and costs for each Supply Area are provided in Appendix 1 to Supporting Report E. Schematics are also available in electronic format in the Data Book.

(6) Technical planning has been undertaken on the assumption that all areas will be supplied from a surface water source by the year 2015, with the exception of isolated farming communities, isolated rural villages and a portion of the demand of Thabazimbi, where a strong groundwater aquifer exists, and Koster where the 2015 demand cannot be met from the local surface water resources. It was further assumed in the planning that all areas that are currently supplied with groundwater of Class 3 or 4 quality will be replaced with a surface water supply by the year 2002, whilst areas with a Class 2 groundwater supply will be replaced with a surface water source by the year 2015.

(7) Although areas that are currently supplied with Class 0 and 1 groundwater could remain on groundwater indefinitely from a quality point of view, it has been considered prudent, for the purposes of the preliminary technical planning, to assume that groundwater supplies of any magnitude offer low security in the long term, and to plan for these villages to be served from surface water sources by the year 2015. This approach is perhaps somewhat conservative, but is considered realistic as the quality of groundwater supplies generally deteriorate with increasing development in a town or village.

(8) In the preliminary planning, little attempt has been made to optimise individual components of bulk supply systems, but rather to identify feasible and realistic options for the provision of new infrastructure, or for the upgrading of existing infrastructure to meet the required demands. The general approach has been to assume that each village or group of adjacent communities will have its own service reservoir, and if reqiured by the topography, its own pumping station and elevated tank. Service reservoirs are costed separately in the schematic layouts. Village water towers and pumping stations have been included in the cost of the reticulations.

The proposed development of the water supply system is shown on the drawing entitled "Proposed Primary Water Supply Infrastructure Development Plan for JICA Study Area".

5.3 Development Planning for the Western Zone

The Western Supply Zone consists of four separate Supply Areas, ie Vaalkop North, Vaalkop South, Barnardsvlei and Koster Supply Areas. The Western Supply Zone is supplied with water from four sources, ie the Elands and Crocodile rivers via Vaalkop Dam, the Hex River from Bospoort Dam, and the Vaal River via Barnardsvlei (supplied by Rand Water). In the near future, primary water from all four of these sources will be consumed within the Greater Rustenburg region, and for this reason these sources have been grouped into a single Supply Zone. The Koster Supply Area has also been included in this Zone, in view of the small, locally-sourced demands that are encountered within this Supply Area.

5.3.1 Vaalkop North Supply Area

Vaalkop Water Treatment Works is located at Vaalkop Dam which forms part of the Crocodile River System and is operated as a unit together with Hartbeespoort Dam and Roodekoppies Dam. The water stored in Vaalkop Dam is supplemented from the Crocodile River using water transferred from Roodekoppies Dam during times of shortfall. Increasing demand will require increasing transfers between these two dams and the treatment works will be extended to meet the rising demand in both the Vaalkop North and Vaalkop South Supply Areas.

The Vaalkop North Supply Area has been subdivided into the following six Supply Blocks, and new infrastrucure proposed for each is described below :

(1) In Thabazimbi Supply Block it is proposed to strengthen the existing south-north pipeline and to provide an additional 15 Ml of storage capacity at Elansfontein SR. It is assumed that conjunctive use of groundwater in Thabazimbi will continue.

(2) Mokgalwaneng Supply Block is located in the far north of Mankwe District. At Northam a secondary rising main branches off to the PPC Cement factory at Dwaalboom. This pipeline is owned by PPC and passes close to villages around Mokgalwaneng. These villages can be supplied from the existing pipeline, although reinforcement will be required up to Modimong. Negotiation with PPC will be required in order to address the matter of supply from a privately owned pipeline.

(3) In Sefikile Supply Block, it is proposed to provide mains and service reservoirs to serve

the the villages near Elansfontein and Mononono by laying a branch off the pipeline feeding Spitskop Reservoir.

(4) Ramokokstad Supply Block will be supplied from a branch off the main Vaalkop - La Patrie pipelines. This Block is currently supplied by groundwater at a very low level of service. The total demand of this Supply Block is small.

(5) Saulspoort Supply Block is supplied from the La Patrie Reservoirs, where water was previously sold in bulk to NWWA. Existing infrastructure within this Block already stretches as far west as Mabeskraal, and is fairly well developed. New extensions to the north and south of this branch pipeline are proposed.

(6) Mogwase Supply Block is currently fed from a branch pipeline off the Vaalkop - La Patrie main, but the existing supply via Mogwase is already at the limit of its capacity, and a future upgrade will be unavoidable. It is proposed to extend the existing system to serve Ledig, Phatsima and the neighbouring communities.

Table 5-1 below presents a summary of additional bulk infrastructure which will be required for the Vaalkop North Supply Area to meet the projected 2015 primary water demand.

Table 5-1 Summary of Additional Bulk Infrastructure Required for Vaalkop North S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Vaalkop		Mld	115
Clear Water P.Station	Vaalkop		kld	150,375
Reservoirs	La Patrie		Ml	40
	Elandsfontein		Ml	15
	Spitskop		Ml	1.5
Pipelines		110 to 200	km	112.13
		250 to 400	km	140.35
		450 to 600	km	62.60
		650 to 800	km	22.50

5.3.2 Vaalkop South Supply Area

An extension, in the form of a large diameter north to south-west pipeline to regional reservoirs at Bospoort (the Vaalkop Southern Supply Block) is about to be implemented to extend the MW supply from Vaalkop WTW. Supply to the Greater Rustenburg region will be made from these reservoirs. Supplies are also made at present from Bospoort WTW at Bospoort Dam to Rustenburg and to RPM.

The Vaalkop South Supply Area has been subdivided into the following two Supply Blocks, each of which was analysed separately.

(1) In the Bethanie Supply Block substantial spare capacity exists due to slow growth in Hartbeesfontein. Current planning proposes that a portion of this be used to implement a new gravity fed regional supply scheme to serve the rural settlements of Modikwe, Berseba and Bethanie.

(2) Vaalkop Southern / Bospoort Supply Block is partly supplied from Bospoort Water Treatment Works which is located at the outlet from Bospoort Dam. The yield of the dam is limited, so supplementary supplies to Rustenburg from Barnardsvlei and Vaalkop are necessary. Bospoort WTW supplies water to Rustenburg TLC and RPM. Rapid urban growth within the Greater Rustenburg region, and growth in the mining demand in the Barnardsvlei Supply Area has resulted in the urgent need for an augmentation scheme to supply the growth points between Bospoort and Barnardsvlei. Water resources investigation and water supply planning identified that this region should be reinforced from Vaalkop WTW, using Crocodile River water. This finding was confirmed by the Study. The proposed scheme comprises a substantial extension of Vaalkop WTW, a rising main to a regional storage reservoirs at Bospoort, and a network of major distribution mains supplying the service reservoirs of bulk consumers within the region. Major consumers to be supplied from the proposed scheme are Rustenburg TLC, the Bafokeng Tribe and Impala Platinum. Potable water will be sold by Magalies Water to Rand Water, probably at the outlet from the Bospoort Reservoirs; Rand Water will in turn sell the water to consumers within its area of supply. The proposed supply from Vaalkop to Rustenburg North, Phokeng and Thlabane will replace the existing supply that is currently imported into this portion of the Supply Block from the Barnardsvlei Supply Area. This solution will reduce the existing primary demand within the Barnardsvlei Supply Area, thereby enabling the existing Rand Water supply from Randfontein to Barnardsvlei to meet demand growth along the Rustenburg to Bapong axis to the year 2015.

Table 5-2 below provides a summary of additional bulk infrastructure which will be required for the Vaalkop South Supply Area to meet the projected 2015 primary water demand.

Table 5-2 Summary of Additional Bulk Infrastructure Required for Vaalkop South S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Vaalkop		Mld	60
Clear Water P.Station	Vaalkop		kld	100,000
Booster P. Station	Townsland		kld	45,000
Reservoirs	Bospoort		Ml	70 (2x35)
Pipelines		110 to 200	km	5.50
		250 to 400	km	23.0
		450 to 600	km	10.0
		650 to 800	km	9.50
		950 to 1,100	km	49.95

5.3.3 Barnardsvlei Supply Area

The Barnardsvlei Supply Area is supplied with water from Rand Water's Zuikerbosch Water Treatment Works on the Vaal Dam through an extensive distribution system, via Witpoortjie and Barnardsvlei reservoirs. No major extensions are proposed within the Barnardsvlei Supply Area during the planning horizon of the Study. Demand growth will be accommodated by discontinuing the existing supply to Rustenburg North, Phokeng and Thlabane, which will be supplied in future from Vaalkop. Rustenburg North, Phokeng and Thlabane have accordingly been included into the Vaalkop South Supply Area.

The Barnardsvlei Supply Area has been subdivided into two Supply Blocks, both supplied from Rand Water's Barnardsvlei Reservoir.

(1) Barnardsvlei Western Supply Block is served by Rand Water's Roodepoort-Barnardsvlei-Rustenburg supply scheme. As discussed under the Vaalkop Southern/Bospoort Supply Block, no augmentation is planned within the Barnardsvlei Western Supply Block within the time frame of the Study, demand growth being met by the proposed discontinuation of the existing export of primary water to the Vaalkop Southern Supply Block.

(2) Barnardsvlei Eastern Supply Block is also fed from Rand Water's Barnardsvlei Reservoir which supplies two separate supply systems owned by Western Platinum. A high pressure system supplies water through a steel pipeline to Jakkelskop Reservoir, Western Platinum Mine and to the Segwaelane. Water is also supplied to the Bapong Supply Unit, but it is proposed that this supply from the north via the mine should be discontinued, and replaced with a direct connection to the proposed new Majakaneng Reservoir in the south. This proposed reservoir against the Magaliesberg, will allow the present pressure tower at Bapong to be taken out of service.

The feasibility of meeting the 2015 demand of the Barnardsvlei Eastern Supply Block from Brits WTW was investigated. The resulting reduction in demand from the

Barnardsvlei Reservoir could, under such a scenario, be applied to meet the 2015 demands of Rustenburg North, Phokeng and Thlabane (which are almost equal to the total demand of the Barnardsvlei Eastern Supply Block). The Vaalkop source to the Vaalkop Southern/Bospoort Supply Block would be relieved of approximately 42 Mld of summer demand, which will in turn be imported from the Barnardsvlei Supply Area. The alternative supply to the Barnardsvlei Eastern Supply Block would be pumped directly from Brits WTW to Majakaneng Reservoir. As for the base case, the Bapong Supply Unit would be fed directly under gravity from Majakaneng Reservoir. The proposed gravity pipeline between Mooinooi and Majakaneng will however, have to operate in the reverse direction (ie east to west), in order to replace the existing supply that is made from Barnardsvlei to Western Platinum Mine, to the Wonderkoppies Supply Unit and to the Segwaelane Supply Unit. The alternative supply to the Barnardsvlei Eastern Supply Block assumes that existing and future demands within this Supply Block can be met from Brits WTW. Since Brits WTW uses the same water resource (the Crocodile River System), as Vaalkop WTW, the results of the water balance study will not be compromised. This alternative however, does not appear from the preliminary calculations to offer a cheaper solution for supply to Rustenburg North, Phokeng and Thlabane than the supply from Vaalkop WTW. In addition, implementing a supply from Brits WTW will present institutional difficulties in the short term, as Brits TLC owns and manages the Treatment Plant at Brits. Neither Magalies Water nor Rand Water has an existing presence or management structure in Brits.

Table 5-3 below provides a summary of additional bulk infrastructure which will be required for the Barnardsvlei Supply Area to meet the projected 2015 primary water demand.

Table 5-3 Summary of Additional Bulk Infrastructure Required for Barnardsvlei S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Pipelines		300	km	13

5.3.4 Koster Supply Area

The Koster Supply Area is supplied from the Elands River and its tributaries. This Supply Area is essentially rural in nature, with no large urban communities, mining or industrial developments. Despite only moderate population growth the water balance study identified surface water shortfalls in the target year 2015. Although sufficient surface water is available in the Crocodile River System (at Vaalkop), the distance from this source is considered to be excessive, and cannot be economically justified in view of the small volumes involved. In future the Koster Supply Area is expected to have to resort to groundwater resources, in order to augment supply.

Each of the following two supply blocks contains only a local supply scheme, providing purified water to the town that forms the core of the block. The remaining area consists of farming communities, and is thus totally dependant on groundwater sources.

(i) Koster Supply Block is supplied from Koster Dam via Koster WTW which will require future upgrading work. This will entail extension of the treatment works and the development of groundwater supplies in the vicinity of the town.

(2) Swartruggens Supply Block is supplied from Swartruggens Dam on the Elands River south of the town. Future upgrading works will comprise a small extension of the treatment works.

Table 5-4 below provides a summary of additional bulk infrastructure which will be required for the Koster Supply Area to meet the projected 2015 primary water demand.

Table 5-4 Summary of Additional Bulk Infrastructure Required for Koster S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Koster		Mld	1.27
Clear Water P.Station	Koster		kld	1,933
Pipelines		140	km	5.0

5.4 Development Planning for the Central Zone

The Central Supply Zone also consists of four separate Supply Areas, ie Brits, Klipvoor, Rand Water and Temba Supply Areas. The Zone is supplied with water from four sources, ie the Crocodile River via Hartbeespoort Dam, the Pienaars and Apies Rivers from the Roodeplaat and Leeukraal dams, the Moretele River via Klipvoor Dam, and the Vaal River via Hartbeeshoek Reservoir (supplied by Rand Water). With the exception of the Rand Water supply via Hartbeeshoek, all of the sources form part of the Upper Crocodile River System, and will be heavily dependant on increasing return flows from the Pretoria-Witwatersrand complex to meet demands in this Supply Zone in future. This heavy reliance on return flows will have an increasingly negative effect on water quality, and special co-operation between the water boards and DWAF will be required to properly monitor and manage water resource quality within the Supply Zone. The individual Supply Areas within the Central Supply Zone are discussed below.

5.4.1 Brits Supply Area

The largest volume of water in the Brits Supply Area is supplied from Brits WTW. A further two treatment works draw water directly from Hartbeespoort Dam which receives extensive return flows from the Pretoria-Witwatersrand complex, mainly via the Hennops River from the Northern Outfall Works. These return flows are generally increasing at a faster rate than the rise in demand within the Brits Supply Area, and an increasing surplus will develop in future in this system, even after allowing for planned increased transfers to Vaalkop Dam during times of shortfall. Historically, Magalies Water has not supplied within the Brits Supply Area. This situation will have to be reviewed by DWAF, with a view to rationalizing the areas of supply of water boards within the Study Area.

The Brits Supply Area has been subdivided into two Supply Blocks, each of which was analysed separately.

(1) Brits Supply Block obtains purified water from Brits WTW which is fed from the Crocodile River. Purified water is pumped from this treatment works into four separate sub-schemes, viz Sonop-Losperfontein, Brits Town, Lethlabile-Jericho and Mothutlung-Madidi. Infrastructure serving Sonop and Losperfontein has sufficient capacity to meet demands in the year 2015, and no upgrading is envisaged within this time frame.

All upgrading needs within the town of Brits will be the responsibility of Brits TLC, and will be in response to specific development initiatives within the town.

The supply to Lethlabile-Jericho is the sub-scheme that will require the most upgrading works within the planning horizon of the Study. Although the existing infrastructure is adequate to meet the 1995 demands, additional pumping plant will be required at Brits WTW in order to meet the envisaged demands to the north of Lethlabile. In addition, the rising main between Brits and Lethlabile will have to be reinforced, while new gravity lines are required between the Lethlabile and Jericho Reservoirs. The villages of Lethlabile, Mboloka, Letlhakaneng, Madinyane and Jericho will be served from the new regional scheme (fixed planning).

The supply from Brits WTW to Mothutlung and Madidi will provide purified water from Brits to Madidi in Odi 1 District. The villages of Damonsville, Mothutlung, Oskraal, Ramogoadi (2) and Lerulaneng are all served along the way. Under this sub-scheme, water will be pumped from the treatment plant all the way to the Oskraal Reservoir, on the western boundary of the Rand Water Supply Area. Draw-offs are made along this line towards the town of Damonsville and Mothutlung to the existing reservoirs serving these towns. From Oskraal Reservoir, water gravitates to Madidi Reservoir. The Oskraal Reservoir is at present still connected to the Ga-Rankuwa Industrial Reservoir in the Rand Water Supply Area. This supply will however be terminated, and all future supplies made from Brits. In order to meet the 2015 demands the rising main between Damonsville and Mothutlung will have to be reinforced. A new pipeline is currently being implemented between Mothutlung and the Oskraal Reservoirs. Additional storage is required at Mothutlung, Oskraal and Madidi.

(2) Hartbeespoort Supply Block (Schoemansville and Cosmos) obtains water directly from Hartbeespoort Dam. Two treatment works purify water drawn directly from Hartbeespoort Dam, for distribution within the villages of Schoemansville and Kosmos. Only an expansion of Schoemansville WTW is proposed for this Block.

Table 5-5 below presents a summary of additional bulk infrastructure which will be required for the Brits Supply Area to meet the projected 2015 primary water demand.

Table 5-5 Summary of Additional Bulk Infrastructure Required for Brits S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Brits		Mld	25
	Hartbeespoort		Mld	11.6
Reservoirs	Lethlabile		Ml	10
Pipelines		200	km	23.40
		300 to 400	km	27.30

5.4.2 Klipvoor Supply Area

The Klipvoor Supply Area has no surface water supply scheme at present. It is essentially rural, and is expected to exhibit slow growth within the planning horison of the Study. In addition, low settlement densities, low income levels and low affordability have, in the past, resulted in little water supply development within this Supply Area. The area falls entirely within jurisdiction of Eastern District Council, and includes no formal towns. The regional water supply scheme proposed for the Supply Area will necessitate the construction of a new water treatment plant downstream of Klipvoor Dam which, in view of its limited size, will require special consideration during the planning stage. Although the treatment works has been sized for continuous operation, it may be cost effective to design the plant to only operate during normal working hours, and to staff and support it from an existing Magalies Water management centre (Vaalkop or Temba/Kudube). Water resources planning shows that the fairly minor 2015 primary demands can be met from Klipvoor Dam, without significant negative effects on supplies elsewhere.

The Klipvoor Supply Area has been subdivided into three Supply Blocks. Under the recommended alternative, all three Supply Blocks will be supplied from the proposed Klipvoor WTW.

(1) The Klipvoor West Supply Block lies to the south and west of the Klipvoor Dam within Odi 1 District. The division between the supply from Brits and the supply from Klipvoor was taken to be the division previously adopted in the fixed planning of the Lethlabile-Jericho sub-scheme. Water from the treatment plant will be pumped to the Klipvoor West Regional Reservoir. From which it will gravitate to a regional/service reservoir serving the village of Legonyane, filling reservoirs supplying the settlements of Fafung and Sephai en-route. Ga Rasai will be served by gravity from the Klipvoor West Reservoir to Fafung pipeline, while supplies to Ga Tsogwe, Ga Tsefoge and Kgomo-Kgomo will be pumped from Legonyane Reservoir. All infrastructure will be new.

(2) The Klipvoor East Supply Block lies to the east, north-east and south-east of Klipvoor Dam within the Odi 1 and Moretele 1 districts and the Moretele North Supply Block lies in the north-east corner of Moretele 1 District. Under the preferred option, water to the Klipvoor West Supply Block, is pumped in an easterly direction to a regional reservoir at Bollantlokwe. At the Bollantlokwe the pipeline splits with water being pumped

through one branch to Slagboom, and eventually Makekeng on the eastern periphery of Moretele North Supply Block, and gravitating southwards along the other branch to Sutelong, from where it is pumped southwards to Rantebeng and Makgabetlwane. At Makgabetlwane the pipeline again splits, with the pumping main continuing in a south westerly direction to Shakung, Buffelsdoorn and Moiletswane; a gravity line feeds from Makgabetlwane in a south-easterly direction to Botshabelo.

As an alternative, the viability of supplying both Klipvoor East and Moretele North Supply Blocks fromTemba WTW was considered. Under this alternative a new pumping station at Temba and a new rising main to Makakeng would be necessary. Although the villages in the two Supply Blocks are linked in the same manner as for the preferred option, the altered source would require that the Slagboom to Makakeng branch be supplied from the opposite direction, with the water being eventually discharged into Bollantlokwe Regional Reservoir. The balance of the supply scheme remains unaltered. The second alternative provided for the Klipvoor East Supply Block to be supplied from the proposed new Klipvoor WTW, and the Moretele North Supply Block to be supplied from Temba WTW. The division between the supply from Kudube and the supply from Klipvoor was taken to be the division previously adopted in the fixed planning of the Moretele 1 Regional Water Supply Scheme. All infrastructure would be new. The preliminary costing showed that the proposed option is likely to represent the most economical solution.

Table 5-6 below presents a summary of additional bulk infrastructure which will be required for the Klipvoor Supply Area to meet the projected 2015 primary water demand.

Table 5-6 Summary of Additional Bulk Infrastructure Required for Klipvoor S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Klipvoor		Mld	3.878
Pumping station	Klipvoor West		kld	731
	Klipvoor East		kld	3,127
	Slagboom		kld	1,171
	Sutelong		kld	889
Reservoirs	Klipvoor West		Ml	1.3
	Sutelong		Ml	1.0
	Bollantlokwe		Ml	0.841
Pipelines		110 to 200	km	183.0

5.4.3 Rand Water Supply Area

The Rand Water Supply Area (consisting of only one Supply Block) is served almost entirely with water imported by Rand Water from its Zuikerbosch WTW below the Vaal Dam. The supply is at present being upgraded from a capacity of 140Mld (peak day) to 300 Mld (peak day).

For the purpose of preliminary planning, it has been assumed that Rand Water will continue its involvement in this Supply Area, but that the supply will be augmented towards the end of the planning horizon from Kudube WTW, to meet the 2015 projected summer day demand of approximately 341 Mld. The water resources availability is such that excess capacity becomes available from the Crocodile River System around 2005. As the augmentation will only be required in the medium to long term, adequate time is available for the various stakeholders to resolve any issues relating to adjusted limits of supply in order to accommodate the proposed supply from Kudube WTW. An option was also investigated under which the entire existing supply by Rand Water would be replaced with an alternative supply from Brits WTW. It is unlikely to be preferable to spend capital to implement a scheme to replace existing infrastructure when other areas remain unserved.

Table 5-7 below presents a summary of additional bulk infrastructure which will be required for the Rand Water Supply Area to meet the projected 2015 primary water demand.

Table 5-7 Summary of Additional Bulk Infrastructure Required for Rand Water S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Kudube		Mld	41
Pumping Stations	Kudube		kld	41,218
Reservoirs	Hartbeeshoek		Ml	138
	Kudube / Temba		Ml	45
Pipelines		110 to 200	km	13.0
		300	km	6.5
		600	km	27.0

5.4.4 Temba Supply Area

The Temba Supply Area is served from the Pienaars and Apies rivers (Roodeplaat and Leeukraal Dams respectively), which are tributaries of the Moretele River and eventually the Lower Crocodile River. There are existing water treatment works operated by Magalies Water at Wallmannsthal, Temba and Kudube. The Wallmannsthal Treatment Works serves the Wallmannsthal Supply Block. Temba serves the Warmbaths/Nylstroom Supply Block while Temba and Kudube can be viewed as a unit, supplying the two other Supply Blocks in Kudube North and Kudube South. Water resources planning shows that the substantial 2015 primary demands in the Temba Supply Area can be met from the Roodeplaat/Leeukraal Dam system, without significant negative effect on primary or non-primary supplies elsewhere.

The Temba Supply Area has been subdivided into four Supply Blocks . No alternatives exist for supply in this Supply Area.

(1) The Kudube North Supply Block follows the east and west banks of the Apies River, between Kudube and Babelegi and the confluence of the Apies and Pienaars rivers. The Block is fed from both Temba WTW (primarily the East Bank supply) and Kudube WTW

(West Bank supply). In the medium to long term these two sources may be used in combination, and water can be transferred to either side of the Apies River as required. At present there is already an inter-connection between the two treatment works.

(2) The Kudube South Supply Block lies in the south-western corner of Moretele 1 District, west of Kudube and north of Soshanguve and Winterveld. The Block is fed from Kudube WTW, which can be augmented from Temba WTW as required. In both Kudube North and South, RDP level presidential lead projects and initiatives to investigate the upgrading from the RDP level of service are underway.

(3) The Wallmannsthal Supply Block mainly supplies nearby small holdings and State institutions . A minor enlargement of Wallmannsthal WTW is likely to be necessary before 2015, but no new pipelines or reservoirs are expected to be required.

(4) The Warmbaths/Nylstroom Supply Block is supplied from Temba WTW. Water is pumped northwards to supply the formal towns of Warmbaths/Belabela and Nylstroom/Phagameng. This system has only recently been commissioned. No significant new facilities are proposed.

Table 5-8 below presents a summary of additional bulk infrastructure which will be required for the Temba Supply Area to meet the projected 2015 primary water demand.

Table 5-8 Summary of Additional Bulk Infrastructure Required for Temba S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Kudube		Mld	48
	Temba		Mld	81
	Wallmannsthal		Mld	2.1
Reservoirs	Kudube/Temba		Ml	114
Pipelines		110	km	3.4
		250	km	4.5
		450	km	3.5
		600	km	4.0

5.5 Development Planning for the Eastern Zone

The Eastern Supply Zone comprises two Supply Areas, the Weltevreden Supply Area and the Bronkhorstspruit Supply Area. This Zone falls largely within the Olifants catchment and the main raw water sources are the Mkombo (Rhenosterkop) Dam on the Elands River in the north (supplemented by water from Loskop Dam) and the Premier Mine Dam on the Wilge River and Bronkhorstspruit Dam on the Bronkhorstspruit in the south. The Zone includes the rural farming areas of Bronkhorstspruit, Cullinan and Moretele 2 districts and the peri-urban area of the former Kwandebele.

Weltevreden WTW and Bronkhorstspruit WTW are linked via the main pipeline running through Kwandebele and there is some flexibility in deciding the split between the two treatment works. Prior to 1996, the yield of Mkombo Dam which is intended to be the main source of raw water to Weltevreden WTW was poor so water was imported from Loskop Dam to make up the shortfall. Following the heavy rainfall at the start of 1996, Mkombo Dam filled up and due to the large storage capacity (206 mcm), water supplies from the dam are assured into the next century. For this reason, the postponement of some of the strengthening work proposed under the Kwandebele Augmentation Scheme has been considered by DWAF and it is probably desirable that more demand than was assumed previously be met from Weltevreden which is located closer to the centre of demand and thus can meet the demand more cost effectively. For the purpose of the water balance and subsequent planning, the existing demarcation between the two Supply Areas was assumed and technical solutions prepared.

Using the existing demarcation, expansion of Weltevreden WTW by 9 Mld (giving 69 Mld capacity) and Bronkhorstspruit WTW by 19.4 Mld (giving 60.4 Mld) is required. The planning for the Kwandebele Augmentation Scheme shows increases in the capacity of Bronkhorstspruit WTW to 57 Mld by 1998 and 69 Mld by 2001. The proposals described below could be reworked if necessary to transfer the 9 Mld demand back to Bronkhorstspruit WTW in which case the demand in 2015 would coincide with the capacity included in the augmentation scheme.

5.5.1 Weltevreden Supply Area

The Weltevreden Supply Area comprises Moretele 2 District and the northern part of Kwandebele. At present, the Moretele 2 is not served by a surface water system and relies heavily on groundwater supplies which are in many places inadequate in terms of quality or quantity. It is therefore proposed that a surface water scheme supplied from Weltevreden be implemented. There is extensive existing water supply infrastructure serving the Kwandebele area as described above and the northern part is supplied from Weltevreden WTW.

The Supply Area is subdivided into four Supply Blocks, i.e. Bloedfontein, Kameelrivier, Mapoch and Waalkraal.

(1) Bloedfontein Supply Block comprises the northern part of Mbibana, and the entire Moutse 1, and Moretele 2 Districts. The former two lie within the former Kwandebele while Moretele 2 formed part of Bophuthatswana. As a result, there is some existing water supply infrastructure in Moutse 1 and Mbibana while Moretele 2 relies completely on inadequate groundwater resources. It is proposed that a surface water scheme be implemented to serve Moretele 2 and the preferred option is that the area is supplied entirely from Weltevreden WTW.

Two alternatives that were considered comprised supplying the villages of Lefiso, Radijoko, Ramantsho, Semohlase and Moletsi from Weltevreden WTW as in the preferred option, while communities in the west of the Block would be served from either the MW treatment works at Temba or from a new water works treating water from Rust de Winter Dam. The water balance indicated that sufficient water resources are available to implement any of these options although water rights for irrigation from Rust de Winter Dam are held by Gauteng Province. Although these have not been taken up in recent years it is understood that a new scheme is now being implemented to use the water for irrigation. For this reason the preferred option of meeting the entire demand from Weltevreden which appears to be slightly more expensive than the Rust de Winter option is proposed. This option has the added benefit of utilising an existing (possibly extended), facility and not necessitating additional staffing and overhead costs associated with constructing an additional treatment works.

From Weltevreden, treated water is pumped to Bloedfontein Regional Reservoir (16 Ml). This supplies Spitspunt Regional Reservoir (2.7 Ml) via a booster pumping station which in turn supplies the surrounding villages in western Moutse 1 by gravity. The proposed new scheme comprises strengthening the pipework and pumps supplying Bloedfontein and Spitspunt reservoirs and providing 4.7 Ml of additional capacity at Spitspunt. A new 450 mm diameter gravity pipeline is proposed running in a south-westerly direction as far as Ga-Ramantshane but booster pumps will be required subsequently at Ga-Ramantshane, Nokaneng, Bamokgoko and Phake B. The new system will extend as far as Pankop at the west end of Moretele 2 and service reservoirs will be provided as required to serve the communities en route. New service reservoirs are required in the parts of Moutse 1 to be supplied from the Spitspunt system.

The villages of Seghoko, Semohlase and Ramantsho fall within Moretele 2 but would be best served by extending the existing system to Loding which would require upgrading to absorb the additional demand. Six small new local service reservoirs (150 to 300 kl) and a new pumping station at Ramantsho are also required in this area to provide the necessary assurance of supply.

Within Moutse 1, the construction of service reservoirs is proposed for communities which are at present served from the Bloedfontein Regional Reservoir without additional local storage. Fixed planning is in place to install gravity pipelines to Tweefontein and Witfontein Agricultural Holdings.

(2) Kameelrivier Supply Block is located south-west of Weltevreden WTW and includes a relatively small peri-urban/rural area served from the treatment works via Leeuwfontein Regional Reservoir, and a rural farming area. New infrastructure comprises an extension of the existing pipeline to Morwe and provision of a service reservoir, a new pumped supply to a service reservoir at Leeuwfontein B.

(3) Mapoch Supply Block comprises a small area located on the north side of the Kameel and Elands rivers and consists of the communities of Mapoch and Thabana which are served from Mapoch Regional Reservoir. New infrastructure proposed comprises only the strengthening of the pipeline to Thabana SR.

(4) Walkraal Supply Block covers most of the northern half of Kwandebele and comprises the area south of the Kameel and Elands rivers as far as the boundary with the Bronkhorstspruit Supply Area. As the system is continuous with that in the Bronkhorstspruit Supply Area, this boundary is not fixed and considerable latitude is available in the Tweefontein area as to whether communities are supplied from Weltevreden or Bronkhorstspruit.

From Weltevreden WTW a 10km long 700 mm diameter rising main delivers into Walkraal Regional Break Pressure Tank and Reservoir (24Ml). Both the main and the tank are adequate to accommodate the projected 2015 demands. From Walkraal, a further 10 km 600 mm diameter rising main supplies Moleti Regional Reservoir which is the main regional reservoir for the distribution system in this Block. Walkraal also supplies Siyabuswa SR (12 Ml) and in addition a new gravity main and local reservoir are proposed to serve Kameelrivier D.

From Moleti Regional Reservoir, four secondary mains supply further regional and local service reservoirs. A 350 mm diameter main supplies most of Moutse 3, forking to supply Matatla and Nganeng in the north-east of the district and villages towards Thabakhubedu in the south. From the northern branch further new branch pipelines and service reservoirs are proposed to serve communities at Mthenti, Kuilsrivier and Mpeleng. Off this main is Stomp Regional Reservoir from which it is proposed to supply six new service reservoirs (sized nominally as 0.15 Ml) to serve villages including Stomp, Mchipisane, Kgobokwane and Maganaubuswa on the south bank of the Elands River. The 250 mm main to the south-east supplies Elandsdoorn Regional Reservoir from which a new supply to a reservoir at Uitspanning and a new extension and reservoir to serve Elandsdoorn B are proposed. A further three reservoirs and associated pipework to serve Elandsdoorn C, Denniton S/H and Kalofane are also included in the proposals.

Two further mains from Moleti Regional Reservoir supply the area to the north-west in a loop which includes Klipplaatdrift Regional Reservoir. Most of the infrastructure is existing but additional new service reservoirs are proposed for Marothobolong, Wolwekraal A, and Twolne (under gravity via a new pipe from Makola). Additional storage is also required to supplement the existing reservoir at Mabhoko.

From Kwaggafontein Regional Reservoir, a 200 mm main runs back in the opposite direction for about 5 km to Mathys Lyn from where it turns to the south-west and supplied Boekenhouthoek Regional Reservoir. New pipelines and reservoirs to supply Matshipe A and Die Bron from this regional reservoir are proposed. Most areas of Kwaggafontein are already served but it is proposed that a new branch pipeline and service reservoir (1.36 Ml) be provided to serve Kwaggafontein D.

Table 5-9 below presents a summary of additional bulk infrastructure which will be required for the Weltevreden Supply Area to meet the projected 2015 primary water demand.

Table 5-9 Summary of Additional Bulk Infrastructure Required for Weltevreden S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Weltevreden		Mld	9
Clear Water PS	Weltevreden		kld	9,345
	Spitspunt		kld	8,848
Reservoirs	Spitspunt		Ml	4.7
	Ga-Ramatshana		Ml	4.8
Pipeline		110 to 200	km	156.2
		250 to 400	km	21.9
		450 to 600	km	27.5
		650 to 800	km	Nil

5.5.2 Bronkhorstspruit Supply Area

The Bronkhorstspruit Supply Area includes Cullinan and Bronkhorstspruit Districts and the southern part of Kwandebele to the south side of Kwaggafontein. The Area has been subdivided into two Supply Blocks, i.e. Bronkhorstspruit and Cullinan. The Kwandebele area is fed from Weltevreden WTW in the north and Bronkhorstspruit WTW in the south and the two systems are linked allowing the demarcation between the two plants to be adjusted according to water resources availability and other factors.

(1) The Bronkhorstspruit Supply Block comprises Bronkhorstspruit and part of Kwandebele as described above and is supplied from Bronkhorstspruit WTW. The treatment works is owned and operated by Bronkhorstspruit TLC and treats water abstracted from the Wilge River which in turn is regulated by Bronkhorstspruit Dam. Under the ongoing Kwandebele Augmentation Project, the yield of Bronkhorstspruit Dam has been increased by raw water transfer from the Grootdraai Dam via the Usutu-Vaal River GWS and there is planning to lay a raw water pipeline from the dam to the treatment works. The treatment works performs a local function but also supplies bulk water to the Ekandustria industrial area and Kwandebele. The augmentation project also provides for the strengthening of bulk potable supply mains in the southern Kwandebele area by additional main laying.

New infrastructure proposed for Bronkhorstspruit Supply Block comprises two additional service reservoirs at Ekandustria, 11 km of main from Tweefontein Regional Reservoir to supply a new reservoir to serve Klipfontein and Kameelpoort, and new service reservoirs to supply Tweefontein M (1.0 Ml) and Enkeldoringoog A (1.5 Ml).

(2) The Cullinan Supply Block comprises mostly rural farming areas with a low population density which rely on groundwater. The only significant water supply scheme is at Cullinan where Magalies Water operates the treatment works which has recently been

uprated to 14.4 Mld. No significant new infrastructure is required within the Block and the treatment capacity is adequate to meet the projected demand in the target year. A slight shortfall in the capacity of Cullinan Regional Reservoir and pipelines and the service reservoir serving Elandia and Protem is projected by the 2015 so uprating just before the end of the planning horizon may be necessary.

Table 5-10 below presents a summary of additional bulk infrastructure which will be required for the Bronkhorstspruit Supply Area to meet the projected 2015 primary water demand.

Table 5-10 Summary of Additional Bulk Infrastructure Required for Bronkhorstspruit S/A

Bulk Infrastructure	Location	Diameter (mm)	Unit	Quantity
Water Treatment Works	Bronkhorstspruit		Mld	19.4
Reservoirs	Ekandustria		Ml	20
	Cullinan		Ml	0.8
Pipeline		110 to 200	km	156.2
		250 to 400	km	21.9
		450 to 600	km	27.5
		650 to 800	km	Nil

5.6 Cost Estimate

The estimated capital expenditure that is required in order to ensure the water supply service-levels predicted for each community or supply unit for the year 2015 are shown on the Planning Schematics for each individual Supply Block, and on the Cost Summary Sheets for each Supply Area and are summarised in Table 5-11, 5-12 and 5-13. The cost of bulk and retail level supply infrastructure was identified from the cost models described under Section 5.1. Bulk infrastructure may be defined as the water supply facilities upstream of the flowmeter on the inlet to a service reservoir and comprises pipework, pumping stations, regional reservoirs, treatment works and raw water pipework. Third Tier or retail costs are associated with the provision of service reservoirs, and the downstream pipework, water towers, pumps and reticulation. For instances where a community is supplied directly from the regional reservoir, the retail costs would normally be for the facilities downstream of a flowmeter on the reservoir outlet. The cost of reticulation was calculated on the Population and Demand spreadsheets. In these spreadsheets the number of properties within each town or village was identified from the population statistics; the development densities were then calculated from the settlement area and the number of properties; finally the reticulation cost per stand or plot was identified by applying the standard cost curves developed for this purpose. Total reticulation costs for a specific settlement were arrived at by multiplying the number of properties for each design year by the unit reticulation cost applicable to the calculated settlement density.

For planning and budgetary purposes, it will be necessary to divide the estimated capital costs between the role players responsible for water supply and sanitation within the Study Area. For this reason, costs were calculated separately for bulk and Third Tier functions. In respect of retail supply costs, there is uncertainty surrounding the capacity of some local authorities to implement water supply projects. In addition, there is an absence of detail as to the exact area of jurisdiction of the various Third Tier organizations, and a lack of clarity as to the extent of involvement of the private sector or of other Government subsidy programmes. These factors prevented a more detailed division of capital costs into specific individual Third Tier organization.

Bulk capital costs for each Supply Area have been apportioned between the RDP level of service portion and the above RDP level of service portion. The apportionment was made pro-rata to the 2015 primary water demand for the RDP level of service, and to the predicted levels of service within the Supply Area under consideration. Apportioned costs have been identified separately for an Accelerated Investment Programme (priority projects), and for a Continuous Investment Programme (other upgrading and expansion projects).

Retail supply costs are also apportioned between the RDP level-of-service portion and the above RDP level of service portion. This apportionment was achieved by establishing from the Population and Demand spreadsheets, those costs that are associated with reticulating all towns and villages within a specific Supply Area to the RDP level of service. The balance of the retail supply costs within the Supply Area were apportioned to the above RDP level of service portion.

An allowance was added to the sub-total for engineering (15 %), VAT (14 %) and contingencies (20 %). The allowance for engineering is estimated on the basis of providing consultancy services for feasibility study, detailed design and construction supervision.

5.7 Recommendations on Sanitation Options

5.7.1 Introduction

The terms of reference for the JICA Study require a study on sanitation with a view to exploring sanitation options for the different levels of service of water supply adopted in the Study.

With regard to the provision of sanitation in the Study Area, the following were the major findings from the Situational Analysis:

(1) Approximately 75 % of the total population in the Study Area use a toilet which falls below the RDP level of a VIP toilet. They comprise about 94 % of the population in non-urban areas and 44 % of the population in urban areas.

(2) The percentage of households which are connected to mains sewerage is 56 % in urban areas and 22 % for the entire Study Area. There is virtually no mains sewerage in non-urban areas but about 6 % of households (4% of the total households in the Study Area) use septic tanks. With regard to the method of domestic wastewater treatment, approximately 72 % of households in the Study Area discharge domestic wastewater (toilet wastewater and other domestic wastewater) into the ground without treatment.

5.7.2 Recommended Sanitation Options

A flow chart for the improvement of sanitation is shown in Figure 5-1.

Improvement of sanitation has two major components as follows :

(1) improvement of the toilet itself; and

(2) improvement of the method for domestic wastewater treatment.

With regard to the first component, it is an urgent priority that improvement to at least the level of RDP should be implemented as soon as practicable over the entire Study Area, as it is part of the short-term sanitation policy of the Government. It is estimated that the total capital cost to achieve this objective will be approximately 350 million Rand.

As for the second component, a careful approach both to the selection of treatment method and to the prioritisation of communities for implementation is required, which must take the following into account :

(1) proximity of the community to both existing and planned mains sewerage;

(2) level of water supply in the community in terms of per-capita water consumption rate and service level (house connection, yard tap or communal tap);

(3) affordability of households in the community;

(4) institutional capacity of the community; and

(5) topographic and environmental considerations.

The flow chart shown in Figure 5-1 has been prepared in accordance with the per-capita water consumption rates of 120 lcd for a house connection, 70 lcd for a yard connection and 30 lcd for a communal tap, which were adopted in the projection of domestic water demand for rural areas. It provides for both on-site and off-site treatment options of domestic wastewater which are suitable for this range of water consumption rates. Technical features of these options are as follows :

Option 1 : Only toilet wastewater will be treated using an on-site septic tank. Other domestic wastewater will be discharged directly into the absorption pit provided at the effluent of the tank.

Option 2 : Both toilet wastewater and other domestic wastewater will be treated using an on-site septic tank.

Option 3 : Both toilet wastewater and other domestic wastewater will be treated using an off-site STED (Septic Tank Effluent Drainage) system with an interceptor tank at each household.

It is recommended that urban areas be provided with mains sewerage.

5.8 Environmental Impact

The Department of Water Affairs and Forestry (DWAF) follows a procedure of Integrated Environmental Management (IEM) for all proposed developments. This IEM procedure consists of certain successive levels of impact studies of which the Relevant Environmental Impact Prognosis (ROIP 1 - the Afrikaans acronym), which relates to a scoping and screening process, is the first. As part of this Study therefore, a ROIP 1 was prepared, a copy of which is included in Part G of the Data Book, and it is proposed that Phase 2 of the Study will include the preparation of a ROIP 2 which will involve a site investigation and input from appropriate specialists if necessary.

An Ecological Task Group is being formed comprising Provincial representatives responsible for environmental management and other interested parties which will address ecological concerns arising from the Study, identify and incorporate independent specialists and authorities, provide guidance in compliance with the IEM procedures and will ensure that environmental considerations receive the necessary attention in the decision making process during the Study and afterwards.

Inevitably, development leads to modifications in the environment and negative environmental impacts which often result from inappropriate management of development activities because of a lack of appreciation of the potential problems. All components of the environment that might be involved were identified so that appropriate ameliorative actions can be integrated with the project as a whole to obtain the best possible results.

Accent was placed on the impact of the proposed pipelines and other related surface structures as these were seen as the elements causing greatest concern. The construction of pipelines, reservoirs and treatment works could have an impact on the socio-economic aspects, i.e land use, settlement, infrastructure and population, and the ecological aspects, i.e. the vegetation, fauna, habitat, changes in flow regime and changes in water quality. Relevant data was extracted from the situational analysis reports to provide baseline information.

The aspects addressed in the ROIP 1 report are:

- the effect of abstraction from dams and the rivers downstream of the dams.
- the impact of the construction of pipelines, pump stations, reservoirs and water towers. The main activities to be expected during the construction of the proposed developments are the following:
  - Pre-construction: Surveying, clearing of vegetation and construction of access routes.
  - During Construction: Typical activities will be clearing of vegetation, stripping and stockpiling topsoil, excavations, disposal of excess material, transport of pipes, drilling, blasting additions or alterations to existing infrastructure and the importation of foreign workers.

- Post-construction and Operational Phase: Rehabilitation of disturbed areas, implementation and maintenance of the pipelines, reservoirs, water towers and pump stations.

The ROIP 1 concluded that:

(1) The construction of pipelines and related infrastructure will not cause substantial disturbance. The environmental consequences associated with these impacts are not considered to be significant if managed during and after construction as stipulated in the environmental management plan.

(2) The impacts of abstraction from dams on the dam itself and downstream of the dams are not considered to be significant, but with a large degree of uncertainty. By determining the in-stream flow requirements of the river, compensation water could then be released. This will influence the yield of the dam and need to be further investigated.

The ROIP 1 report recommended that the following be determined during Phase 2 for establishing the feasibility of the scheme:

(1) Social impacts

Undertake a socio-economic investigation to ascertain the following:

(a) The social and economic impacts associated with construction disturbances on the farming activities along the pipeline routes:

(b) This investigation should include meetings with the local communities to determine:
(i) the interested and affected parties
(ii) the preferences of the communities to any options or alternative developments.

(2) Ecological impacts

Confirm the statement that the downstream impacts associated with the proposed scheme will be minimal in view of the existing degraded river stretches.

Investigate the need for a study of the status quo of the existing river stretches to be impacted upon. Aspects to be borne in mind with the in-stream impacts are:

- flow regime and aquatic biota;
- riparian vegetation.

To be undertaken if the scheme is proven to be feasible:

- Compile an Environmental Management Plan for the construction phase and draw up appropriate rehabilitation guidelines to mitigate the disturbance and aesthetic impacts caused by the construction of the pipeline and associated infrastructure.

- Alert the contractor and labourers to the ecological and social impacts associated with construction activities.
- Landscaping specification for the river and canal crossings.
- An archaeological and historical sites reconnaissance survey of the proposed pipeline routes is recommended.
- General rehabilitation measures.
- Identify birds and their nesting sites where appropriate.
- Fish survey where appropriate.
- Identification of exotic aquatics.
- Define suitable operating rule for dams taking into account the recreational and tourism activities as well as downstream ecological requirements.
- Determine the in-stream flow requirement of the rivers downstream of dams in order to determine the amount of water to be released as compensation water.
- Liaise with all interested and affected parties.

Table 5-11 : Summary of Costs from Infrastructure Planning - Western Zone

	VAALKOP NORTH	VAALKOP SOUTH	BARNARD-SVLEI	KOSTER	ZONE TOTAL
Bulk Supply Costs					
Direct Costs					
WTW	41,666	21,667	0	423	63,756
Regional SR	16,067	15,920	0	0	31,987
PS	2,600	9,435	0	410	12,445
Pipelines	172,096	116,170	6,071	685	295,022
Sub Total	**232,429**	**163,192**	**6,071**	**1,518**	**403,210**
Indirect Costs					
Engineering	34,864	24,479	911	228	60,482
VAT	37,421	26,274	977	244	64,916
Contingency	60,943	42,789	1,592	398	105,722
Sub Total	**133,228**	**93,542**	**3,480**	**870**	**231,120**
Bulk Total	**365,657**	**256,734**	**9,551**	**2,388**	**634,330**
Retail Supply Costs					
Direct Costs					
SR	9,206	3,956	2,828	1,036	17,026
Reticulation	84,350	92,423	24,440	3,120	204,333
Pipework	6,302	849	0	0	7,151
Sub Total	**99,858**	**97,228**	**27,268**	**4,156**	**228,510**
Indirect Costs					
Engineering	14,979	14,584	4,090	623	34,276
VAT	16,077	15,654	4,390	669	36,790
Contingency	26,183	25,493	7,150	1,090	59,916
Sub Total	**57,239**	**55,731**	**15,630**	**2,382**	**130,982**
Retail Total	**157,097**	**152,959**	**42,898**	**6,538**	**359,492**
TOTAL	522,754	409,693	52,449	8,926	993,822

Table 5-12 : Summary of Costs from Infrastructure Planning - Central Zone

	BRITS	KLIPVOOR	TEMBA	RAND	ZONE TOTAL
Bulk Supply Costs					
Direct Costs					
WTW	16,312	6,938	42,785	13,507	79,542
Regional SR	2,800	1,676	23,450	30,833	58,759
PS	312	931	0	3549	4,792
Pipelines	22,189	24,415	7,343	27,811	81,758
Sub Total	**41,613**	**33,960**	**73,578**	**75,700**	**224,851**
Indirect Costs					
Engineering	6,242	5,094	11,037	11,355	33,728
VAT	6,700	5,468	11,846	12,188	36,202
Contingency	10,911	8,904	19,292	19,849	58,956
Sub Total	**23,853**	**19,466**	**42,175**	**43,392**	**128,886**
Bulk Total	**65,466**	**53,426**	**115,753**	**119,092**	**353,737**
Retail Supply Costs					
Direct Costs					
SR	4,980	3,180	39,243	49,500	96,903
Reticulation	34,109	19,475	37,353	174,920	265,857
Pipework	0	0	0	0	0
Sub Total	**39,089**	**22,655**	**76,596**	**224,420**	**362,760**
Indirect Costs					
Engineering	5,863	3,398	11,489	33,663	54,413
VAT	6,293	3,647	12,332	36,132	58,404
Contingency	10,249	5,940	20,083	58,843	95,115
Sub Total	**22,405**	**12,985**	**43,904**	**128,638**	**207,932**
Retail Total	**61,494**	**35,640**	**120,500**	**353,058**	**570,692**
TOTAL	**126,960**	**89,066**	**236,253**	**472,150**	**924,429**

Table 5-13 : Summary of Costs from Infrastructure Planning - Eastern Zone

	WELTER-VREDEN	BRONKHORST-SPRUIT	ZONE TOTAL
Bulk Supply Costs			
Direct Costs			
WTW	2,984	6,471	9,455
Regional SR	3,158	10,773	13,931
PS	2,584	0	2,584
Pipelines	65,929	2,456	68,385
Sub Total	**74,655**	**19,700**	**94,355**
Indirect Costs			
Engineering	11,198	2,955	14,153
VAT	12,019	3,172	15,191
Contingency	19,574	5,165	24,739
Sub Total	**42,791**	**11,292**	**54,083**
Bulk Total	**117,446**	**30,992**	**148,438**
Retail Supply Costs			
Direct Costs			
SR	14,703	2,967	17,670
Reticulation	214,101	77,495	291,596
Sub Total	**228,804**	**80,462**	**309,266**
Indirect Costs			
Engineering	34,321	12,069	46,390
VAT	36,837	12,954	49,792
Contingency	59,992	21,097	81,090
Sub Total	**131,150**	**46,121**	**177,271**
Retail Total	**359,954**	**126,583**	**486,537**
TOTAL	**477,400**	**157,575**	**634,975**

'igure 5-1 : Flow Chart for Improvement of Sanitation